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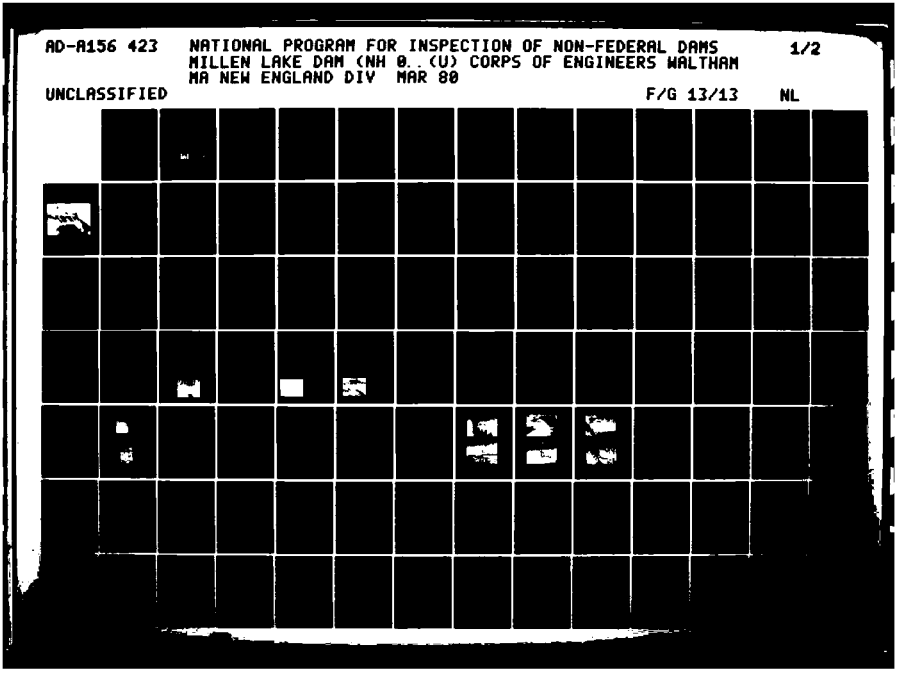
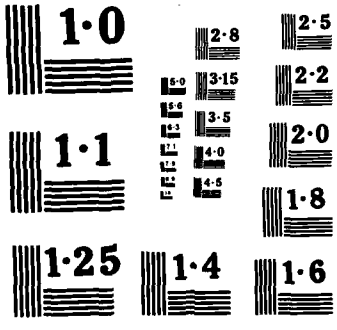




CONNECTICUT RIVER BASIN

WASHINGTON, NEW HAMPSHIRE

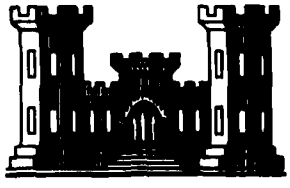
MILLEN LAKE DAM

NH 00236

NHWRB NO. 245.04

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

MARCH 1980

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle) Millen Lake Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Connecticut River Basin
Washington, New Hampshire
Millen Lake

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THe dam is an earthfill gravity structure about 23 ft. high and 115 ft. long. The dam is considered to be in fair condition. It is intermediate in size with a significant hazard potential. There are various recomendations that should be implemented by the owner.

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REPLY TO
ATTENTION OF:

NEDED

JUL 07 1980

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen.

Inclosed is a copy of the Millen Lake Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, Millen Lake Association, Inc., Ardmore, Pennsylvania.

Copies of this report will be made available to the public upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely,

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

MILLEN LAKE DAM
NH 00236
NHWRB 245 4

CONNECTICUT RIVER BASIN
WASHINGTON, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No: NH 00236

Name of Dam: Millen Lake Dam

Town: Washington

County and State: Sullivan, New Hampshire

Stream: Millen Lake

Date of Inspection: December 6, 1979

Millen Lake Dam is an earthfill gravity structure approximately 23 feet high from crest of dam to toe of slope and about 115 feet long. The upstream face consists of a concrete and mortared stone retaining wall which extends from crest of dam vertically downward to the lake bottom. The crest width is approximately 42 feet and is an asphalt paved town road. Located in the center of the dam is the principal spillway and sluice gate structure which both discharge into a common concrete inlet box. Flow from this box enters a 48-inch diameter corrugated aluminum pipe which runs beneath the roadway and discharges at the toe of the downstream slope. There is no emergency spillway incorporated as part of the dam structure.

The dam impounds Millen Lake and the discharge flows through an unnamed brook in a southwesterly direction for approximately 0.8 miles to Ashuelot Pond. It is reported that the dam was originally constructed for industrial purposes, but its present use is recreational. The reservoir is 1.31 miles in length with a surface area of about 156 acres. The maximum storage capacity is about 1,285 acre-feet.

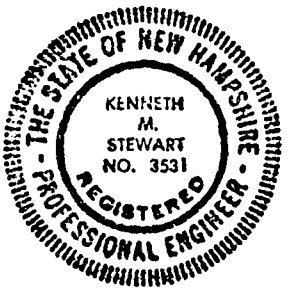
As a result of the visual inspection and the review of available data regarding this facility, the dam is considered to be in FAIR condition. Major concerns are: lack of vegetation on the downstream slope and on the upstream and downstream edges of the crest render these areas less resistant to erosion; minor settlement of the crest in the vicinity of the buried spillway conduit; and trees growing on the abutments and downstream slope.

This dam is classified as INTERMEDIATE in size and a SIGNIFICANT hazard structure in accordance with the recommended guidelines established by the Corps of Engineers.The test flood for this dam, therefore, ranges from one-half the Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). The full PMF was utilized for this hydrologic analysis. The test flood inflow was estimated to be 3,320 cfs, and resulted in a routed test flood outflow equal to 890 cfs which would overtop the dam crest by about 0.3 feet. The maximum spillway capacity (assuming that the sluice gate is closed) with the water

level at the dam crest was estimated to be 89 cfs or about 10 percent of the routed test flood outflow. However, this is not considered to be a serious limitation of the dam since more than 80 percent of the routed test flood outflow bypasses the dam via a stream channel located approximately 1,000 feet from the dam on the west shore of the lake. A major breach with the reservoir surface at the dam crest would destroy the town road over the dam and would increase the stage of the immediate downstream channel to nearly 14 feet resulting in damage to the residence located directly behind the dam. Water would rise to approximately 2 feet above the sill of the house. The potential for loss of less than a few lives exists.

It is recommended that the owner engage a qualified registered professional engineer to design or specify erosion protection for the crest and downstream slope of the dam, to investigate the cause of settlement of the crest in the vicinity of the buried spillway conduit to specify and oversee procedures for the removal of trees and their root systems from the abutments and downstream slope of the dam and to do a detailed hydrologic-hydraulic investigation to assess further the potential of overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and the means to increase project discharge capacity. Included in the hydrologic-hydraulic investigation should be an examination of the need for maintaining the secondary stream channel outlet located upstream from the dam. It is also recommended that the owner clear the trees from a zone 25 feet wide on either side of the downstream channel for a distance of 100 feet below the dam.

The recommendations and remedial measures are described in Section 7 and should be addressed by the owner within one year after receipt of this Phase I Inspection Report.



Kenneth M. Stewart
Project Manager
N.H.P.E. 3531

S E A Consultants Inc.
Rochester, New Hampshire

This Phase I Inspection Report on Millen Lake Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

ARAMAST MAHTESIAN, MEMBER
Geotechnical Engineering Branch
Engineering Division

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

RICHARD DIBUONO, CHAIRMAN
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and

rarity of such a storm event, finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespassing and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

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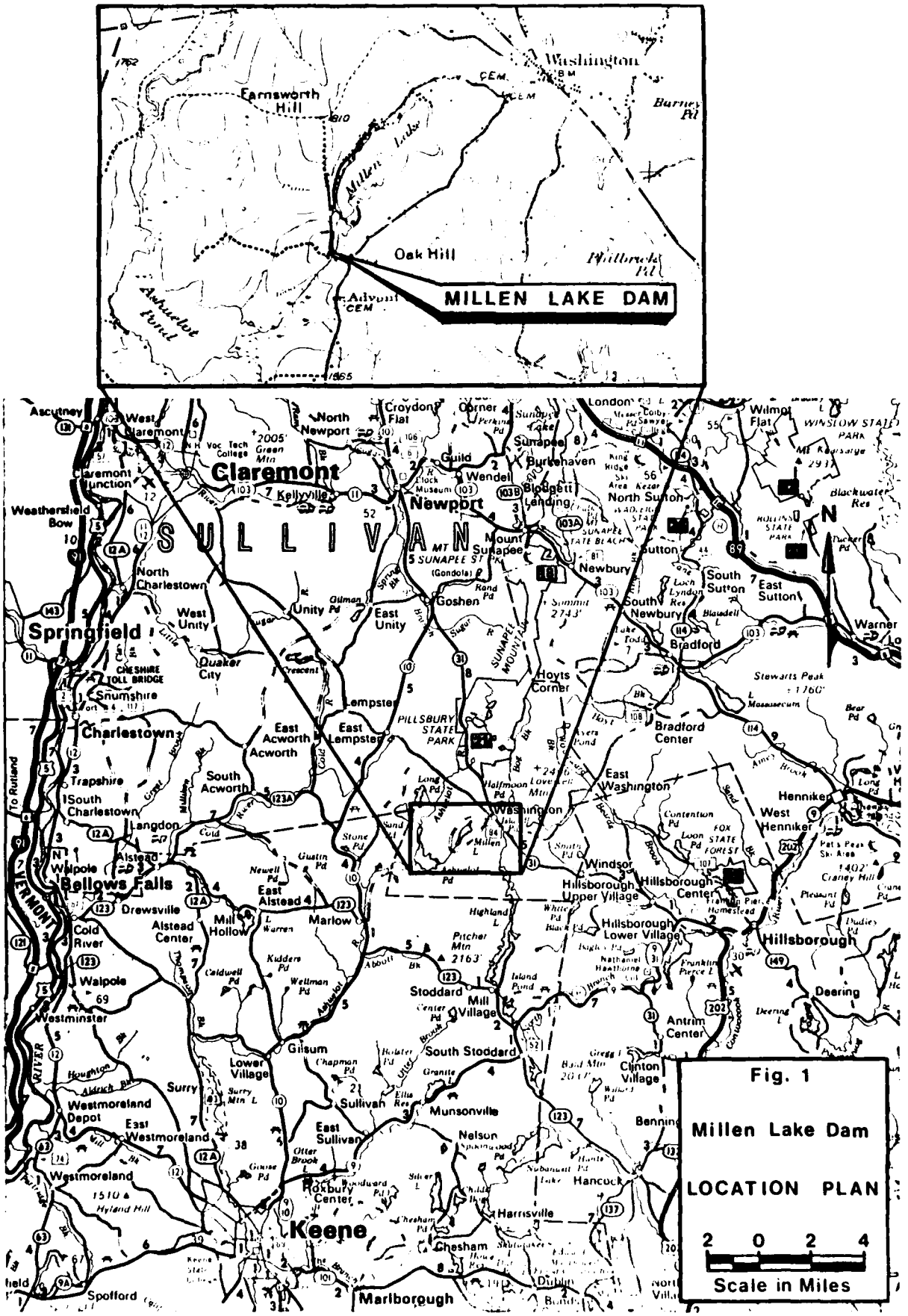
OVERVIEW PHOTO - MILLEN LAKE DAM


Washington
Farnsworth Hill
Oak Hill
MILLEN LAKE DAM
SULLIVAN
Claremont
Newport
Springfield
Charlestown
Bellows Falls
Keene
Marlborough
Hillsborough
Fig. 1
Millen Lake Dam
LOCATION PLAN
2 0 2 4
Scale in Miles

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
MILLEN LAKE DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. S E A Consultants Inc. has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed were issued to S E A Consultants Inc. under a letter of November 5, 1979 from William Hodgson, Jr., Colonel, Corps of Engineers. Contract No. DACW33-80-C-0008 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Millen Lake Dam is located in the Town of Washington, New Hampshire, at the south end of the Millen Lake, under Faxon Hill Road. The dam impounds water from Millen Lake, which after passing over the spillway, flows through an unnamed brook in a southwesterly direction for approximately 0.8 miles where it discharges into Ashuelot Pond. The dam is shown on U.S.G.S. Quadrangle, Lovewell Mountain, New Hampshire, with coordinates approximately N43°09'05", W72°07'39", Sullivan County, New Hampshire. (See Location Plan)

b. Description of Dam and Appurtenances. Millen Lake Dam is an earthfill gravity structure, with a concrete and mortared stone face wall, approximately 23 feet high from crest of dam to toe of slope and about 115 feet in length. The upstream face consists of a concrete and mortared stone retaining wall which

extends from crest of dam vertically downward to the lake bottom. The downstream slope is approximately 1 foot vertical to 2 feet horizontal (1:2) from crest of dam to toe of slope. The crest width is approximately 42 feet and is asphalt paved.

Located in the center of the dam is the principal spillway and gate structure which consists of a steel gate located at the lake bottom which discharges into a 3 feet wide by 3 feet high stone box sluiceway. Located directly above the gate is the spillway which consists of a 4 feet wide by 3 feet high concrete box culvert. The concrete box culvert and stone lined box sluiceway extend about 12 feet until they both discharge into a common concrete inlet box. Flow from the inlet box enters a 48 inch diameter corrugated aluminum pipe which runs beneath Faxon Hill Road and discharges at the toe of the downstream slope.

c. Size Classification. Intermediate (height 23 feet, storage - 1,285 acre-feet) based on storage (greater than or equal to 1,000 acre-feet and less than 50,000 acre-feet) as given in the Recommended Guidelines for Safety Inspection of Dams.

d. Hazard Classification. Significant Hazard. A major breach in the Millen Lake Dam could result in damage to the residence located directly behind the dam. Water would rise to approximately 2 feet above the sill of the house. In addition to the possible damage to the house, the town road over the dam would be destroyed. The potential for loss of less than a few lives exists.

e. Ownership. Land titles on file at the Sullivan County Registry of Deeds, Newport, New Hampshire indicate that in 1857, Faulkner and Colony Manufacturing Company bought up several large tracts of land in an area just southwest of the Town of Washington, to construct a dam and create an artificial lake for industrial purposes, known as Millen Lake. Faulkner and Colony went bankrupt in the mid 1950's, and it is not known to whom the ownership of the dam was transferred at that time. Records show that in 1970, the owner was the Keene Housing Authority, who conveyed the dam in the same year to the present owner, Millen Lake Association, Inc. The person in responsible charge of the dam for the Association is Donald Callendar, President, Millen Lake Association, 2944 Morris Road, Ardmore, Pennsylvania 19003. Telephone No. (215) 642-0112.

f. Operator. The dam is operated by Mark Basto, Millen Lake Road, Washington, New Hampshire 03280. Telephone No. (603) 495-3619.

g. Purpose of Dam. The original purpose of the dam was to create an artificial body of water, called Millen Lake, for industrial purposes by a Faulkner and Colony Manufacturing Company. Faulkner and Colony went bankrupt in the mid 1950's and the present purpose of the dam is recreational.

h. Design and Construction History. Land deeds indicate that in 1857, Faulkner and Colony Manufacturing Company bought several large tracts of land in order to construct a dam and create an artificial lake for industrial purposes, known as Millen Lake. The actual date of construction of the dam or date when water was first impounded is not known. The earliest records on file at the State of New Hampshire Water Resources Board show the dam to be in existence in 1937.

The dam was reconstructed in July of 1970 by Curtis Rowe of Hillsboro, New Hampshire. This work consisted of a new face wall of concrete, a new 48 inch corrugated aluminum pipe for an outlet, and stone riprap on the downstream slope around the discharge of the outlet pipe.

An as-built sketch was prepared by P.E. Rolfe, Professional Engineer, Washington, New Hampshire, in November 1970 and is on file at the State of New Hampshire Water Resources Board.

i. Normal Operating Procedures. The Millen Lake Dam is used primarily to retain the water of Millen Lake for recreational purposes. The normal operating procedure for this dam is to lower the water level in October approximately 2 feet (plus or minus) so that debris along the edge of the lake can be removed and repairs made to docks. The lake is usually not brought up to normal pool level until spring. When the lake is lowered during the winter, a conscious effort is made to keep the level at an elevation which will maintain flow in a stream channel approximately 1,000 feet upstream from the dam. This flow provides a source of water for livestock raised along the stream. This channel represents a secondary outlet to Millen Lake, and essentially functions as an emergency spillway for the dam.

1.3 Pertinent Data

a. Drainage Area. The drainage area above the Millen Lake Dam covers an area of approximately 1.23 square miles (787 acres), consisting of steeply sloped terrain. The topography in the basin ranges from over 1960 feet (NGVD) to below 1580 feet at the base of the dam face. The majority of the drainage area is heavily wooded. Development is predominantly located along the western edge of the lake and consists of a combination of year round and summer residences.

b. Discharge at Damsite. The outlet works consist of a 4 feet wide by 3 feet high concrete box spillway and a gated, 3 feet square stone box sluiceway. The spillway and sluiceway connect to a common concrete inlet box about 12 feet behind the face of the dam. Flow entering the inlet box leaves through a 48 inch diameter corrugated aluminum pipe. This pipe passes through the dam and discharges to the stream channel at the toe of the dam. The spillway weir is set at approximately 1582.0 feet above mean sea level, and the water surface is maintained near that elevation throughout most of the year. During the winter months, the reservoir is lowered about 2 feet by opening the sluice gate. This gate can be used to lower the reservoir to an elevation of 1572.9 feet.

(1) The capacity of the sluiceway was estimated to be 155 cfs with the water surface at the top of dam (elevation 1587.2 feet) and 157 cfs with the water surface at the test flood elevation (elevation 1587.5 feet).

(2) Maximum known flood at damsite - unknown

(3) The capacity of the ungated spillway with the water surface at the top of the dam (at elevation 1587.2 feet) was estimated to be 89 cfs.

(4) The capacity of the ungated spillway with the water surface at the test flood elevation (at elevation 1587.5 feet) was estimated to be 92 cfs.

(5) N/A

(6) N/A

(7) The total spillway capacity at the test flood elevation was estimated to be 92 cfs.

(8) The total project discharge at top of dam was estimated to be 660 cfs with the sluice gate closed (89 cfs spillway, 571 cfs channel upstream from the dam) and 815 cfs with the sluice gate open (89 cfs spillway, 155 cfs sluiceway, 571 cfs channel upstream from dam).

(9) The total project discharge at the test flood elevation was estimated to be 890 cfs with the sluice gate closed (92 cfs spillway, 746 cfs channel upstream from dam, 52 cfs over dam crest).

c. Elevation (feet, NGVD) based on elevation 1582.0 shown on U.S.G.S. quad sheet assumed to be pool elevation at top of permanent spillway crest

(1) Streambed at toe of dam - 1564.0

(2) Bottom of cutoff - unknown

(3) Maximum tailwater - unknown

(4) Recreation pool - 1582.3

(5) Full flood control pool - N/A

(6) Spillway crest - 1582.0

(7) Design surcharge (Original Design) - unknown

(8) Top of dam - 1587.2

(9) Test flood design surcharge - 1587.5

d. Reservoir (length in feet)

(1) Normal pool - 6,940

(2) Flood control pool - N/A

(3) Spillway crest pool - 6,930

(4) Top of dam - 7,125

(5) Test flood pool - 7,135

e. Storage (acre-feet)

(1) Normal pool - 465

(2) Flood control pool - N/A

(3) Spillway crest pool - 420

(4) Top of dam - 1285

(5) Test flood pool - 1,340

f. Reservoir Surface (acres)

(1) Normal pool - 156

(2) Flood control pool - N/A

(3) Spillway crest - 156

(4) Test flood pool - 179

(5) Top of dam - 177

g. Dam

(1) Type - earthfill gravity structure with concrete and mortared stone face wall

(2) Length - 115 feet

(3) Height - 23 feet maximum

(4) Top Width - 42 feet

(5) Side Slopes - upstream - vertical face wall to lake bottom
- downstream - 1V to 2H earth to toe of slope

(6) Zoning - unknown

(7) Impervious core - unknown

(8) Cutoff - unknown

(9) Grout curtain - none

(10) Other - none

h. Diversion and Regulating Tunnel

Not applicable (see Section j below)

i. Spillway

(1) Type - concrete, discharge into 4 feet wide by 3 feet high concrete box culvert

(2) Length of weir - 4.0 feet

(3) Crest elevation - 1582.0 (permanent crest)

(4) Gates - N/A

(5) U/S Channel - Millen Lake. The banks are tree lined. The slopes of the lake appear stable. No evidence of significant sedimentation was observed. The approach channel is wide and unobstructed.

(6) D/S Channel. The outlet works discharge to a natural stream channel at the toe of the downstream slope of the dam. The stream channel is approximately 10 feet wide at the base, with steeply sloping tree-lined banks. The channel becomes broader and less steep as it enters Ashuelot Pond approximately 0.8 miles downstream from the dam.

j. Regulating Outlets

(1) Invert - Sluice gate - 1572.9 bottom of gate opening

(2) Size - Sluice gate - 3.0 feet x 3.0 feet stone lined culvert

(3) Description - Sluice gate - one steel gate with 3.0 feet x 3.0 feet opening

(4) Control Mechanism - Sluice gate - opened and closed mannually by 3 inch by 1-1/4 inch steel channel gate stem secured by chain and padlock.

SECTION 2
ENGINEERING DATA

2.1 Design

No design data were disclosed for Millen Lake Dam.

2.2 Construction

A sketch on file at the State of New Hampshire Water Resources Board indicates a reconstruction of the Millen Lake Dam occurred in July of 1970, and the work was performed by Curtis Rowe of Hillsboro, New Hampshire. This sketch shows "as-built" detail and was prepared by P.E. Rolph, Professional Engineer, Washington, New Hampshire and dated November 12, 1970.

2.3 Operation

No engineering operational data were found.

2.4 Evaluation

a. Availability. No engineering data were available for Millen Lake Dam, other than the "as-built" sketch described in Section 2.2. A search of the files of the State of New Hampshire Water Resources Board and contact with the Selectmen for the Town of Washington, revealed a limited amount of recorded information.

b. Adequacy. The final assessments and recommendations of this investigation are based on the visual inspection and the hydrologic and hydraulic calculations.

c. Validity. The field investigation indicated that the external features of the Millen Lake Dam substantially agree with those shown on the "as-built" sketch mentioned in Section 2.2. The only apparent differences are that the slope of the 48 inch diameter corrugated, aluminum outlet pipe does not agree with that indicated on the "as-built" sketch, and no dumped stone is present on the downstream slope as indicated on the "as-built" sketch.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. Millen Lake Dam impounds a lake of intermediate size. The watershed above the dam consists of steeply sloped terrain surrounding Millen Lake. The majority of the drainage basin is heavily wooded. Development is predominantly located along the western edge of the lake and consists of a combination of year round and summer residences. The downstream area is heavily wooded and undeveloped.

The field inspection of Millen Lake Dam was made on December 6, 1979. The inspection team consisted of personnel from S E A Consultants Inc. and Geotechnical Engineers, Inc. Inspection checklists, completed during the visual inspection, are included in Appendix A. At the time of inspection, no water was passing over the spillway. The pool elevation was at approximately 1582.0 feet (NGVD). The upstream face of the dam could only be inspected above this water level.

b. Dam. Millen Lake Dam is an earthern embankment about 23 feet high, 115 feet long, and 42 feet wide at the crest. (See Photo No. 2.)

There is a paved roadway on the crest of the dam. (See Photo No. 7.) The shoulders of the roadway, out to the upstream and downstream edge of the crest, consist of sand and gravel, and have practically no vegetation. (See Photo No. 7.) The roadway has settled a few inches in the vicinity of the spillway conduit which passes under it. (See Plans and Details in Appendix B.) Two logs, which are supported against trees, retain the top 1 to 2 feet of fill at the downstream edge of the crest and some erosion of the fill, apparently due to runoff from the roadway, has occurred on the downstream edge of the crest. (See Photo No. 8.)

The upstream face of the dam is retained by a stone-masonry retaining wall which is in good condition. (See Photo Nos. 3, 4 and 5.) A concrete facing has been constructed against this wall up to an elevation about 4 inches above the overflow spillway crest. (See Photo No. 6 and Plans and details in Appendix B.)

The downstream slope of the embankment is inclined at 1V:2H and consists of sand, gravel, and boulders. (See Photo Nos. 8, 9 and 10.) Two large trees are growing near the top of the slope, and several trees are growing near the downstream toe of the slope. The slope is practically bare of any other vegetation. There was no evidence of seepage on the downstream slope or in the area downstream of the toe of the dam.

Both abutments appear to consist of soil. Bedrock appears to be exposed on both sides of the valley bottom immediately downstream of the dam. Trees are growing on the upstream and downstream sides of both abutments, approximately at the elevation of the crest of the dam, or slightly lower. (See Photo Nos. 5 and 7.)

c. Appurtenant Structures. Located in the center of the dam is the principal spillway and gate structure which consists of a steel gate located at the lake bottom which discharges into a 3 feet wide by 3 feet high stone box sluiceway (See Photo No. 6 and Plans and Details in Appendix B). Located directly above the gate is the spillway which consists of a 4 feet wide by 3 feet high concrete box culvert, with a wire mesh covering the entrance. The concrete box culvert and stone lined box sluiceway extend about 12 feet until they both discharge into a common concrete inlet box. Flow from this inlet box enters a 48 inch diameter corrugated aluminum pipe which runs beneath Faxon Hill Road and discharges at the toe of the downstream slope (See Photo No. 10). The sluice gate control mechanism consists of a 3 inch by 1-1/4 inch steel channel gate stem rising through a 4 inch diameter iron pipe (See Photo No. 6). The gate stem is secured by chain and padlock and is operated manually. The spillway, sluiceway, gate and stem, and all other works relating to this structure appear to be in good condition and were operable at the time of inspection.

d. Reservoir Area. The slopes of the reservoir appear to be stable. No evidence of significant sedimentation was observed. Trees are growing on the banks of the approach channel upstream of the dam, but the channel is wide and unobstructed (See Photo No. 1).

e. Downstream Channel. One tree has fallen across the channel immediately downstream of the dam, and many trees overhang the channel (See Photo Nos. 11 and 12).

3.2 Evaluation

On the basis of the results of the visual inspection, Millen Lake Dam is considered to be in fair condition.

The lack of vegetation on the shoulders next to the paved roadway on the crest of the dam and also on the downstream slope of the dam leaves those areas subject to erosion by rainfall runoff or in case of overtopping, by flowing water. Erosion which has already started on the downstream edge of the crest will act as a focus for more intense erosion as time goes on.

The two logs which retain the top 1 to 2 feet of fill on the downstream edge of the crest will eventually rot and break, allowing the edge of the crest to slump and making it more susceptible to erosion.

Minor settlement of the crest in the vicinity of the spillway conduit which passes under the crest appears to be evidence of poor compaction of the backfill around the conduit when it was reconstructed. If the backfill is poorly compacted, it could be susceptible to seepage and piping problems.

Trees growing on the abutments and downstream slope could lead to seepage and piping problems if a tree blows over and pulls out its roots, or if a tree dies or is cut and its roots rot.

SECTION 4
OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General. The Millen Lake Dam is used primarily to retain the waters of Millen Lake. The normal operating procedure for this dam is to lower the water level in the month of October approximately 2 feet (plus or minus) so that debris along the edge of the lake can be removed and repairs made to docks.

b. Description of Any Warning System in Effect. No written warning system exists for the dam.

4.2 Maintenance Procedures

a. General. The owner, the Millen Lake Association, is responsible for the maintenance of the dam. A general inspection and cleaning of debris from the spillway and gate chamber is usually made in October when the water level is lowered.

b. Operating Facilities. No formal plan for maintenance of operating facilities was disclosed.

4.3 Evaluation

The current operation and maintenance procedures for the Millen Lake Dam are inadequate to insure that all problems encountered can be remedied within a reasonable period of time. The owner should establish a written operation and maintenance procedure, as well as establish a warning system to follow in event of flood flow conditions or imminent dam failure.

SECTION 5
EVALUATION OF HYDROLOGIC/HYDRAULIC FEATURES

5.1 General. The Millen Lake Dam is an earthfill gravity structure approximately 23 feet high from crest of dam to toe of slope and 115 feet long. The spillway consists of a 4 feet wide by 3 feet high stone box culvert, which discharges into a concrete inlet box. Flow from the box culvert enters a 48 inch corrugated aluminum pipe which discharges to the stream channel at the toe of the dam. Located below the spillway structure is a gated 3 feet by 3 feet sluiceway, which also discharges to the concrete inlet box when the gate is opened. Outflow from Millen Lake also occurs through a stream channel located approximately 1000 feet upstream from the dam on the west shore of the lake. Discharge through this channel is controlled by a 24 inch corrugated aluminum culvert which passes beneath the road located about 500 feet from the edge of the lake. The invert of this culvert is more than 2 feet lower than the spillway invert, therefore, water normally flows through this channel during the entire year. In fact, a conscious effort is made to maintain the flow so that water from this stream channel can be used to water livestock. The roadway has been constructed on fill deposited across the original stream channel. This layer of fill is about 4 feet deep near the culvert and quickly thins out to the original ground surface on each side of the culvert. Consequently, this road does not represent a significant barrier across the stream channel.

The drainage area above the dam consists of steeply sloped terrain which is heavily wooded. No other impoundments, which would delay the arrival of runoff to Millen Lake, are located in the drainage area. The dam impounds a lake which functions as a recreation facility. The dam is classified as intermediate in size, having a maximum storage of approximately 1285 acre-feet.

5.2 Design Data. No hydrological or hydraulic design data were disclosed.

5.3 Experience Data. No experience data were disclosed. Maximum flood flows or elevations are unknown.

5.4 Test Flood Analysis. Due to the absence of detailed design and operational information, the hydrologic evaluation was performed utilizing data gathered during field inspection, watershed size and an estimated test flood determined from the Corps of Engineers guide curves. For this dam (intermediate size and significant hazard) the test flood ranges from one-half the Probable Maximum Flood (1/2 PMF) to the full Probable Maximum Flood (PMF). The full PMF was selected for this analysis in order to show the relative hydrologic significance of the secondary stream channel outlet on the west shore of the lake. Since the drainage area consists of steeply sloping terrain, the "mountainous" curve, from the Corps of Engineers set of guide curves, was used to estimate the maximum probable flood peak flow rate.

Based on an estimated maximum probable flood peak flow rate of 2700 cfs per square mile and a drainage area of 1.23 square miles, the test flood inflow was estimated to be 3320 cfs. The test flood was routed through the reservoir in accordance with the Corps of Engineers procedure for Estimating Effect of Surcharge Storage on Maximum Probable Discharge. The reservoir water surface was assumed to be at elevation 1582.0 prior to the flood routing. The routed test flood outflow was estimated to be 890 cfs. This analysis indicated that the dam crest would be overtopped by 0.3 feet. The maximum spillway capacity (assuming that the sluice gate is closed) with the water level at the dam crest was estimated to be 89 cfs, which is only about 10 percent of the test flood discharge. It was estimated that 746 cfs, which is more than 80 percent of the routed test flood outflow, would bypass the dam via the stream channel located upstream from the dam. This flow would overtop the roadway by nearly 3 feet.

5.5 Dam Failure Analysis. The impact of dam failure was assessed utilizing the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs published by the Corps of Engineers. The analysis covered a reach extending approximately 0.8 miles downstream to Ashuelot Pond. The prefailure flow is negligible (about 2 percent of the peak failure outflow from an assumed breach), so prefailure tailwater conditions were not included in the calculations and the dam failure analysis was conducted with the water surface at the dam crest. Based on this analysis, the Millen Lake Dam has been classified as a significant hazard.

An assumed breach in the Millen Lake Dam with the water surface at the dam crest would increase the stage of the immediate downstream channel to nearly 14 feet and consequently, could damage the residence located directly behind the dam. Water would rise to approximately 2 feet above the sill of the house. Further downstream, the stage would be reduced to about 3 feet as the stream channel widens before discharging into Ashuelot Pond. The stage would be quickly reduced to approximately 1 foot when the flow enters the pond. In addition to the possible damage to the house behind the dam, the road over the dam would also be destroyed. The potential for loss of less than a few lives exists.

SECTION 6
EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

The visual inspection indicates the following potential structural problems:

(1) Lack of vegetation on the downstream slope and on the upstream and downstream edges of the crest, which leaves those areas subject to erosion.

(2) Erosion on the downstream edge of the crest which, if not controlled, could lead to breaching of the dam.

(3) Use of logs, which will eventually rot and break, to retain the top 1 to 2 feet of fill on the downstream edge of the crest.

(4) Minor settlement of the crest in the vicinity of the buried spillway conduit, which may be evidence of poor compaction of the backfill around the conduit.

(5) Trees growing on the abutments and downstream slope which could lead to seepage or erosion problems if a tree blows over and pulls out its roots or if a tree dies or is cut and its roots rot.

6.2 Design and Construction Data

No data regarding the original design or construction of the dam was found. It is believed that the first dam structure was built shortly after land purchases were made in 1857 for construction of the artificial lake.

6.3 Post-Construction Changes

The dam was reconstructed in July of 1970 by Curtis Rowe of Hillsboro, New Hampshire. This work consisted of a new face wall of concrete, a new 48 inch corrugated aluminum pipe for an outlet, and stone riprap on the downstream slope around the discharge of the outlet pipe.

An as-built sketch was prepared by P.E. Rolfe, Professional Engineer, Washington, New Hampshire, in November 1970. This sketch indicates the cross section of the embankment to be "dirt and rock fill", but no engineering data about the properties of the embankment material are given. No information about the foundation of the dam is given. The sketch indicates that dumped rock was to be placed on the entire downstream slope, but at the time of the inspection, the downstream slope consisted of sand, gravel and boulders, and a small amount of riprap around the discharge of the outlet pipe.

6.4 Seismic Stability

This dam is located in Seismic Zone 2 and, in accordance with the Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination indicates that Millen Lake Dam is in fair condition. The major concerns with respect to the integrity of the dam are:

(1) Lack of vegetation on the downstream slope and on the shoulders of the paved roadway on the crest of the dam.

(2) Erosion on the downstream edge of the crest of the dam.

(3) Use of logs to retain the top 1 to 2 feet of fill on the downstream edge of the crest of the dam.

(4) Minor settlement of the crest of the dam in the vicinity of the buried spillway conduit.

(5) Trees growing on the abutments and downstream slope.

(6) Inadequacy of the spillway to pass the test flood.

b. Adequacy of Information. The information available from the visual inspection and hydraulic analysis is adequate to identify the problems that are listed in 7.2. These problems will require the attention of a qualified registered professional engineer who will have to make additional engineering studies to design or specify remedial measures. No additional information is needed for the purpose of this Phase I investigation.

c. Urgency. The owner should implement the recommendations in 7.2 and 7.3 within one year after receipt of this Phase I report.

7.2 Recommendations

The owner should retain a registered professional engineer qualified in the design and construction of dams to:

(1) Design or specify erosion protection for the crest and downstream slope of the dam, including repair of the erosion that has already occurred on the downstream edge of the crest.

(2) Investigate the cause of settlement of the crest in the vicinity of the buried spillway conduit and design remedial measures if needed.

(3) Specify and oversee procedures for the removal of trees and their root systems from the abutments and downstream slope of the dam.

(4) Do a detailed hydrologic-hydraulic investigation to assess further the potential for overtopping the dam, the adequacy of the spillway to pass the test flood, and the need for and means to increase project discharge capacity. Included in the hydrologic-hydraulic investigation should be an examination of the need for maintaining the secondary stream channel outlet located upstream from the dam.

7.3 Remedial Measures

a. Operating and Maintenance Procedures. The owner should:

(1) Repair masonry wall on right abutment.

(2) Clear the trees from a zone 25 feet wide on either side of the downstream channel for a distance of 100 feet below the dam.

(3) Visually inspect the dam and appurtenant structures once each month.

(4) Engage a registered professional engineer qualified in the design and construction of dams to make a comprehensive technical inspection of the dam once every one year.

(5) Establish a surveillance program for use during and after heavy rainfall, and also a warning program to follow in case of emergency conditions.

7.4 Alternatives

There are no practical alternatives to the recommendations of Section 7.2 and 7.3.

APPENDIX A

INSPECTION CHECKLIST

INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT: Millen Lake Dam, NH

DATE: December 6, 1979

TIME: 2:00 P.M.

WEATHER: Cool, pretty cloudy

W.S. ELEV. 1582.0 U.S. 1564.8 DN.S.
(NGVD)

PARTY:

1. Kenneth Stewart, S E A
2. Robert Durfee, S E A
3. Bruce Pierstorff, S E A
4. Philip Ricardi, S E A
5. Ronald Hirschfeld, GEI
6.
7.
8.
9.
10.

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	Structural Stability	K. Stewart/R. Durfee	
2.	Hydrology/Hydraulics	B. Pierstorff/P. Ricardi	
3.	Soils and Geology	R. Hirschfeld	
4.			
5.			
6.			
7.			
8.			
9.			
10.			

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Dam Embankment NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
DAM EMBANKMENT	
Crest Elevation	1587.2
Current Pool Elevation	1582.0
Maximum Impoundment to Date	Unknown
Surface Cracks	None observed
Pavement Condition	Good
Movement or Settlement of Crest	Irregular settlement of crest near upstream side in vicinity of spillway
Lateral Movement	None observed
Vertical Alignment	See "Movement or Settlement of Crest"
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Good
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	Road shoulders on crest are bare of vegetation
Vegetation on Slopes	Trees growing on upstream and downstream side of abutments; trees growing at downstream toe of dam
Sloughing or Erosion of Slopes or Abutments	Erosion of downstream side of crest
Rock Slope Protection - Riprap Failures	No riprap
Unusual Movement or Cracking at or near Toe	None observed
Unusual Embankment or Downstream Seepage	None observed
Piping or Boils	None observed
Foundation Drainage Features	None observed
Toe Drains	None observed
Instrumentation System	None observed

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Dike Embankment NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
DIKE EMBANKMENT	No dike
Crest Elevation	
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	
Pavement Condition	
Movement or Settlement of Crest	
Lateral Movement	
Vertical Alignment	
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	
Indications of Movement of Structural Items on Slopes	
Trespassing on Slopes	
Vegetation on Slopes	
Sloughing or Erosion of Slopes or Abutments	
Rock Slope Protection - Riprap Failures	
Unusual Movement or Cracking at or near Toe	
Unusual Embankment or Downstream Seepage	
Piping or Boils	
Foundation Drainage Features	
Toe Drains	
Instrumentation System	

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Intake Channel NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE	
a. Approach Channel	
Slope Conditions	Good
Bottom Conditions	Good
Rock Slides or Falls	None
Log Boom	None
Debris	Minor - leaves and twigs against screen protecting gate
Condition of Concrete Lining	Not applicable
Drains or Weep Holes	None
b. Intake Structure	
Condition of Concrete	Mortared stone - good
Stop Logs and Slots	None

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Control Tower NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - CONTROL TOWER	No control tower
a. Concrete and Structural	
General Condition	
Condition of Joints	
Spalling	
Visible Reinforcing	
Rusting or Staining of Concrete	
Any Seepage or Efflorescence	
Joint Alignment	
Unusual Seepage or Leaks in Gate Chamber	
Cracks	
Rusting or Corrosion of Steel	
b. Mechanical and Electrical	
Air Vents	
Float Wells	
Crane Hoist	
Elevator	
Hydraulic System	
Service Gates	
Emergency Gates	
Lightning Protection System	
Emergency Power System	
Wiring and Lighting System	

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Transition and Conduit NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - TRANSITION AND CONDUIT	Concrete conduit leading to 48" diameter corrugated pipe not accessible
General Condition of Concrete	
Rust or Staining on Concrete	
Spalling	
Erosion or Cavitation	
Cracking	
Alignment of Monoliths	
Alignment of Joints	
Numbering of Monoliths	

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Outlet Structure NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	48" diameter corrugated metal pipe
General Condition of Concrete	Not applicable
Rust or Staining	None
Spalling	Not applicable
Erosion or Cavitation	Not applicable
Visible Reinforcing	Not applicable
Any Seepage or Efflorescence	Not applicable
Condition at Joints	Not visible
Drain holes	None
Channel	
Loose Rock or Trees Overhanging Channel	Trees overhanging channel
Condition of Discharge Channel	Fair

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Spillway Weir NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	None
Floor of Approach Channel	Not visible beneath reservoir surface
b. Weir and Training Walls	
General Condition of Concrete	Good
Rust or Staining	None observed
Spalling	None
Any Visible Reinforcing	None
Any Seepage or Efflorescence	None
Drain Holes	None observed
c. Discharge Channel	
General Condition	Good
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Several overhanging trees. One tree has fallen into channel immediately downstream of discharge outlet.
Floor of Channel	Natural - loose stone
Other Obstructions	None

INSPECTION CHECK LIST

PROJECT: Millen Lake Dam, NH DATE: December 6, 1979

PROJECT FEATURE: Service Bridge NAME: _____

DISCIPLINE: _____ NAME: _____

AREA EVALUATED	CONDITIONS
OUTLET WORKS - SERVICE BRIDGE	No service bridge
a. Super Structure	
Bearings	
Anchor Bolts	
Bridge Seat	
Longitudinal Members	
Under Side of Deck	
Secondary Bracing	
Deck	
Drainage System	
Railings	
Expansion Joints	
Paint	
b. Abutment & Piers	
General Condition of Concrete	
Alignment of Abutment	
Approach to Bridge	
Condition of Seat & Backwall	

APPENDIX B

ENGINEERING DATA

AVAILABLE ENGINEERING DATA

A sketch dated 1970 showing "as-built" detail of plan and section for reconstruction of the Millen Lake Dam is available at the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301.

PAST INSPECTION REPORTS

M E M O

Date: December 10, 1979

To: Vernon A. Knowlton,
Chief Engineer

From: Ken Stern,
Water Resources Engineer

Subject: Corps Inspection of Millen Lake Dam, No. 245.04, Washington

On December 6, 1979 I visited the site prior to the inspection team from SEA Consultants.

The dam is approximately 18 ft. high, 75 ft. long and 35 ft. wide. It is a combination concrete, stone and earth structure with a paved road on the crest.

The upstream channel restricts flow to the dam. There is a high level spillway and a deep gate which is operated.

The potential damage, should the dam fail, would be to the road which is the dam and a house downstream. The house is a summer house and is well above the main channel but flows overtopping the dam could erode soil from the building foundation.

The items noted in need of attention are:

1- Trees growing on the downstream slope.

2- The erodible downstream slope.

3- There is no apparent gate lifting mechanism but the gate is operated.

I believe any action on this dam can wait until the report is received.

KS:paf

View from downstream

NEW HAMPSHIRE WATER RESOURCES BOARD

INSPECTION REPORT

Town: WASHINGTON Dam Number: 245.04

Name of Dam, Stream and/or Water Body: MILLEN LAKE

Owner: TOWN OF WASHINGTON Telephone Number:

Mailing Address: TOWN HALL WASHINGTON

Max. Height of Dam: 15± Pond Area: 14B Length of Dam: 100'

FOUNDATION: EARTH

OUTLET WORKS: SPILLWAY LEADING TO DROP INLET TO 48" CMP

ABUTMENTS: STONE

EMBANKMENT: ROAD FILL - EARTH

Note: Give Sizing, Condition and detailed description for each item, if applicable.

Dam No. _____

SPILLWAY: Length: 3.8' Freeboard: 4.0'

SEEPAGE: Location, estimated quantity, etc.

NONE OBSERVED

Changes Since Construction or Last Inspection:

RECONSTRUCTION OF ~~THE~~ ROAD & INSTALLATION OF NEW CULVERT.

Tail Water Conditions:

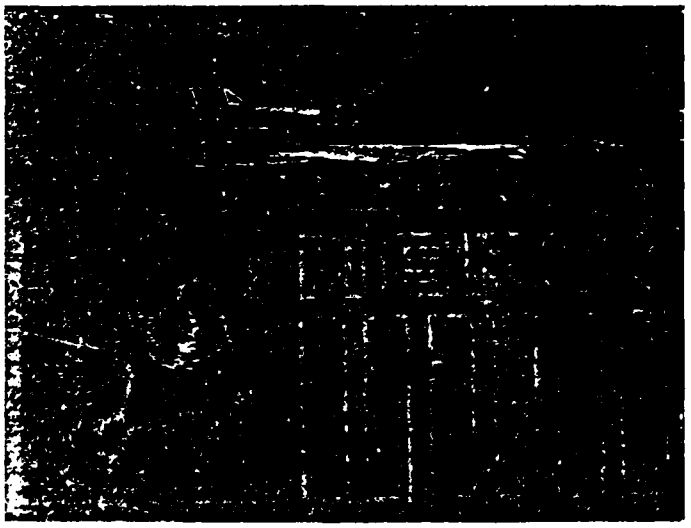
WOOD & STREAM

Overall Condition of Dam: GOOD

Contact With Owner: NO

Date of Inspection: 2 DEC 77 Suggested Reinspection Date 1982

Class of Dam: MINAGE - PONDAGE + ROAD



Signature Gary L. Keer

Date 2 DEC 77

Note: Give Sizing, Condition and detailed description for each item, if applicable.

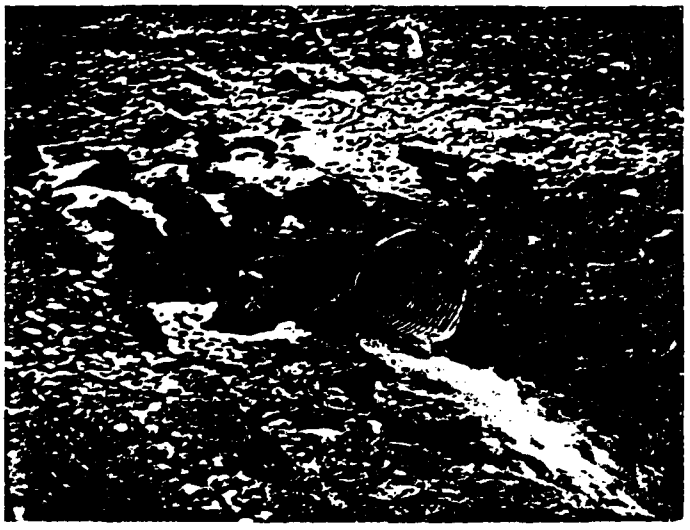
Dam No. _____

COMMENTS:

1) 0.7' OVERSPILLWAY CREST.

2) SLIGHT SNOW COVER

3) POND TOO HIGH TO INSPECT GATE



OUTLET PIPE

Dam No._____

SKETCH OF DAM (Show Plan, Elevation & Cross Sections)

SEE DETAIL PLAN SUBMITTED W/ S & E.

DATE: October 13, 1970

FROM: Francis C. Moore
Water Resources Engineer

SUBJECT: Outlet Culvert at Millen Pond,
Washington #245.04

TO: Vernon A. Knowlton
Chief Water Resources Engineer

On June 9, 1970, I visited Millen Pond at request of Abner Barker, Washington Selectman, concerning the condition of the outlet at Millen Pond dam. The masonry retaining walls to the roadway over the outlet tunnel was falling away from the wall. Also, the masonry in the outlet tunnel was deteriorating with some large stones shifting into the tunnel. The tunnel and roadway retaining wall were in disrepair.

Abner Barker said they wanted to replace the present outlet tunnel with a pipe culvert. I said that this could be done but that the plans for the culvert outlet pipe should be reviewed by Water Resources Board prior to the placement. He said he was going to talk with New Hampshire Public Works and Highway Dept. concerning this work.

On October 10, 1970, after hearing that the culvert had been placed, I visited the Millen Pond dam. A 48" aluminum corrugated pipe outlet pipe - about 40 feet long - had been laid. The former outlet was about 3' to 4' wide and about twelve feet high. If the 48" pipe culvert has a 12 1/2% grade it would pass a 100 year frequency flood flow. The grade of the pipe was not determined but it did not appear to be over 10%. The distance from the spillway downstream slab to the drop chamber wall did not appear to be sufficient during extreme flows. It was difficult to see how much it was without a measuring rod as there is now a masonry slab above this chamber.

No Special Board permit nor probably a variance by Water Supply and Pollution Control Commission were obtained. No plans were submitted to the Water Resources Board. In my opinion, any storm over 50 year frequency could overtop the embankment.

FCM/jb

DATE: June 10, 1970

FROM: Francis C. Moore
Water Resources Engineer

SUBJECT: Millen Pond Outlet Sluiceway - 254.04 - Washington

TO: Vernon A. Knowlton, Chief Engineer
N. H. Water Resources Board

On June 9, 1970, I inspected the condition of the road culvert immediately downstream of Millen Pond spillway at request of Abner Barker of Washington, Selectman Since last inspection, September 26, 1969, the downstream east side of the dry masonry wall along the sluiceway culvert has shifted toward the west. This movement is at least 4 inches just under the capstone and is 8" to 12" just above the bottom of the wall closing off slightly the sluiceway opening. This movement apparently has been caused by heavy construction trucks passing over the culvert on way to Ashuelot Lake Shores development. The road now is restricted by sign to 6 Ton Gross Load.

The Town wished to replace this 12' high by 3' wide culvert by a corrugated metal culvert pipe. They are also requesting the Keene Division Engineer of Public Works and Highways Department to inspect and offer suggestions. I have heard that the dam owner, now Millen Lake Association, is responsible for the sluiceway outlet channel. However, in my mind, this condition has been caused by impact of very heavily loaded trucks passing it until now without any load limits.

Millen Pond has a drainage area of only 1.23 sq. mi. and a pond area of 148 acres. The 15 year frequency flood flow is 161 c.f.s. and 100 year frequency flow of 325 c.f.s. There is about 2' drop in 20' in the culvert channel. A 54 inch CM pipe will carry 325 c.f.s. with a slope of 0.07. A 48 inch pipe carries 325 c.f.s. with a 0.125 slope and a 60" with a 0.04 slope carries 325 c.f.s.

It is suggested that a 54" CM culvert pipe be installed with its inlet invert elevation at or below the bottom of the gate opening in the dam and sloped not less than 2' in 28' or 3' in 40' length. An opening just below the dam spillway at least 30" long and the full width of the channel, 4', must be maintained but can be screened for safety. The side walls should be pointed up but not faced with concrete (which would reduce the space). A headwall from bottom to top should be built of concrete to prevent all leakage along culvert pipe.

As the road will be widened to TRA standards, the downstream face will be sloped and probably faced with riprap from channel and downstream wall excavation. The brook channel below the present masonry downstream face should be cleared of loose boulders to allow better stream flow.

It is suggested that the Town present any plans of the culvert installation to this Board in detail.

FCM/jb

MEMORANDUM

TO: Vernon A. Knowlton, Water Resources Engineer

RE: Inspection of Millen Lake Dam, Washington - #245.04

On September 26, 1969, I inspected Millen Lake dam and emergency outlet in Washington, New Hampshire. This inspection was made to determine what essential work was needed to safely operate the dam with a minimum of effort.

The following work should be completed:

(1) Between the road and the outlet spillway there is a planked over opening that is a potential highway menace. To correct this, a removable concrete slab 3' wide with 2' along line of stream should cover the hole. This cover should be able to support a concentrated load of 4 tons without failing. To do this, the sides of the hole should be concreted up a distance of about 2 1/2 feet from stones down that depth. About 1 1/2 cubic yards of concrete is involved which includes considerable form work. Some provision for a small grating in the cover should be made for local surface drainage.

(2) Just downstream of the outlet spillway there is a cap stone on the wall that has an opening several inches wide. This hole should be concreted to prevent injury to people walking along the dam.

(3) There are many trees between the masonry facing of the dam and the roadway and one large maple just upstream of the east end of the masonry wall that should be cleared. If uprooted by wind, they might tear a hole in the top of dam.

(4) The area between the masonry dam and the highway should be graded, fertilized, seeded and mulched to make a more pleasing appearance and to provide improved drainage.

(5) The opening below the outlet spillway under the roadway should have all loose stones, wood and debris removed to improve the outlet conditions.

(6) At the emergency outlet about 600 yards north of the outlet dam, there is a 24-inch corrugated metal outlet pipe with invert located about 0.2 feet below the main spillway concrete crest. The approach channel to this pipe should be cleared of brush and vegetation and deepened at the thread of stream from the pond to at least six inches below the invert of the entrance to the pipe culvert to improve flow conditions.

It is estimated that the total cost to accomplish the above six noted items would be approximately $1,000.00.

Suggested operation of this dam is to lower the level of Millen Pond by four feet in the late fall and then close the gate completely except for very minor flow to provide a minimum of fish water in the brook. The lake would fill by the end of spring runoff. In case of exceptionally high spring flood flows, the gate could be opened to provide for the unusually high flows during this high runoff period.

This pond has a freeboard of only two feet two inches above the outlet spillway concrete before it overflow the road north of the dam. This is only a little over three inches of runoff from the total drainage area to the point the pond overflows the road.

Francis C. Moore
Water Resources Engineer

fcm?c
cc: K.Brighton

7205

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON RESERVOIRS & PONDS IN NEW HAMPSHIRE

LOCATION AT DAM NO. 245.04

Town Washington : County Sullivan

Stream Miller Lake

Basin—Primary Conn. R. : Secondary Ashuelot R.

Local Name

DRAINAGE AREA

Controlled ..... Sq. Mi.: Uncontrolled ..... Sq. Mi.: Total 2.25 Sq. Mi.

ELEVATION vs. WATER SURFACE AREA vs. VOLUME

Point	Head Feet	Surface Area Acres	Volume Acre Ft.
(1) Max.-Flood Height			
(2) Top of Flashboards			
(3) Permanent Crest			
(4) Normal Drawdown		148.41	
(5) Max. Drawdown			
(6) Original Pond			

Base Used ..... : Coef. to change to U.S.G.S. Base .....

RESERVOIR CAPACITY

	Total Volume	Useable Volume
Drawdown	..... ft.	..... ft.
Volume	..... ac. ft.	..... ac. ft.
Acre ft. per sq. mi.	.....	.....
Inches per sq. mi.	.....	.....

USE OF WATER Storage for (Industrial)

OWNER Faulkner & Colony Mfg. Co.

REMARKS

Tabulation By RL T Date 9/22/39

NEW HAMPSHIRE WATER CONTROL COMMISSION
DATA ON DAMS IN NEW HAMPSHIRE

LOCATION STATE NO. 245.04

Town Washington: County Sullivan

Stream Millen Lake

Basin-Primary Conn.R.: Secondary Ashuelot R.

Local Name

Coordinates—Lat.: Long.

GENERAL DATA

Drainage area: Controlled Sq. Mi.: Uncontrolled Sq. Mi.: Total 2.25 Sq. Mi.

Overall length of dam 93 ft.: Date of Construction

Height: Stream bed to highest elev. 14 ft.: Max. Structure 11 ft.

Cost—Dam: Reservoir

DESCRIPTION Road&Culvert, stone&earth

Waste Gates

Type sluice Type

Number 1: Size 2 ft. high x 3 ft. wide

Elevation Invert 8.0: Total Area 6 sq. ft.

Hoist

Waste Gates Conduit

Number: Materials

Size ft.: Length ft.: Area sq. ft.

Embankment

Type

Height—Max. ft.: Min. ft.

Top—Width: Elev. ft.

Slopes—Upstream on: Downstream on

Length—Right of Spillway: Left of Spillway

Spillway

Materials of Construction stone

Length—Total 4 ft.: Net ft.

Height of permanent section—Max. 11 ft.: Min. ft.

Flashboards—Type: Height ft.

Elevation—Permanent Crest: Top of Flashboard

Flood Capacity cfs.: cfs/sq. mi.

Abutments

Materials:

Freeboard: Max. 3 ft.: Min. ft.

Headworks to Power Devel.—(See "Data on Power Development")

OWNER Faulkner&Colony Mfg.Co.

REMARKS Leaks at base. Condition good
Use-Storage for Industry.

Tabulation By RLT Date 9/22/39

B&B21284

NEW HAMPSHIRE WATER RESOURCES BOARD

INVENTORY OF DAMS AND WATER POWER DEVELOPMENTS

DAM

BASIN Connecticut No. 4 215.04
RIVER Millen Lake MILES FROM MOUTH 0.9 D.A.SQ.MI 2.25
TOWN Washington OWNER Faulkner & Colony Mfg. Co. Rockingham Co. Penacook N.H.
LOCAL NAME OF DAM
BUILT _____ DESCRIPTION Stone Dam Stone and earth
Road & culvert Highway over
Stone & earth

POND AREA-ACRES 148.41 P.S. DRAWDOWN FT. _____ POND CAPACITY-ACRE FT.
HEIGHT-TOP TO BED OF STREAM-FT. 8 12 MAX. _____ MIN. _____
OVERALL LENGTH OF DAM-FT. 293 MAX.FLOOD HEIGHT ABOVE CREST-FT. _____
PERMANENT CREST ELEV.U.S.G.S. _____ LOCAL GAGE _____
TAILWATER ELEV.U.S.G.S. _____ LOCAL GAGE _____
SPILLWAY LENGTHS-FT. 4 FREEBOARD-FT. 3
FLASHBOARDS-TYPE, HEIGHT ABOVE CREST _____
WASTE GATES-NO. WIDTH MAX.OPENING DEPTH SILL BELOW CREST
1 3 2 8.0'

REMARKS Condition Good
3 I Into Ashuelot Pond, Ashuelot 2, Connecticut R.
Outlet Ashuelot Pond 55.7 mi from Mouth Ashuelot R.

POWER DEVELOPMENT

UNITS NO.	RATED HP	HEAD FEET	C.F.S. FULL GATE	KW	MAKE

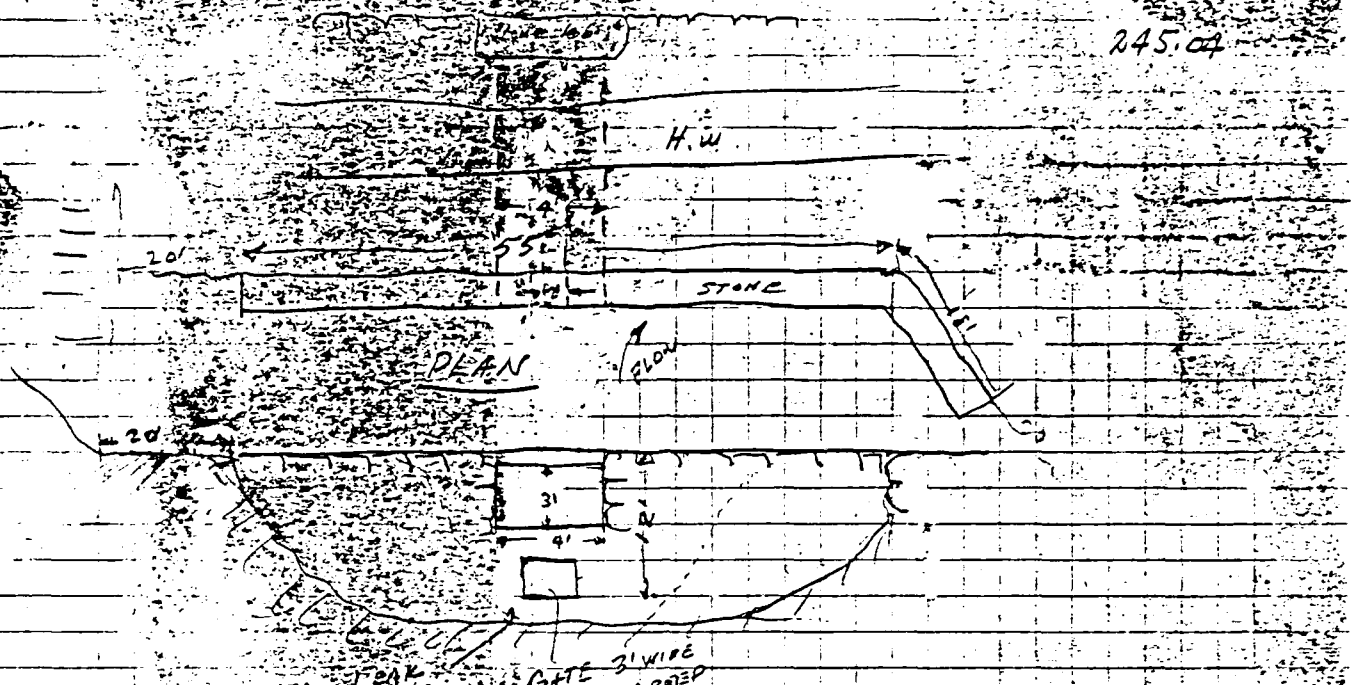
USE Storage

REMARKS Info from W. E. Faulkner Jr. who accompanied us to dam

DATE 1925 Est.
9/23/37 L + S Sts

FAULKNER LAKE DAM - OUTLET MELLEN L. WASHINGTON 9/23/77

245.0

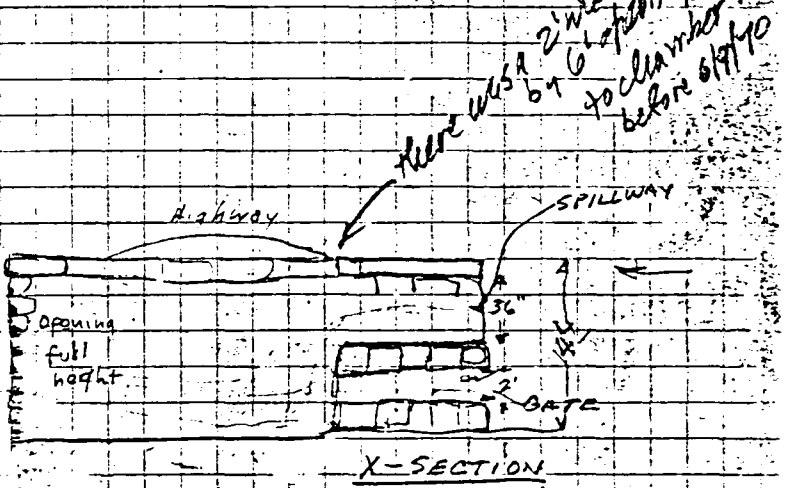


PROFILE

TYPE - STONE

CONDITION - GOOD (LEAKS AT BASE)

GATE RAISED BY CHAIN - KEPT LOCKED



X-SECTION

No. 245.04

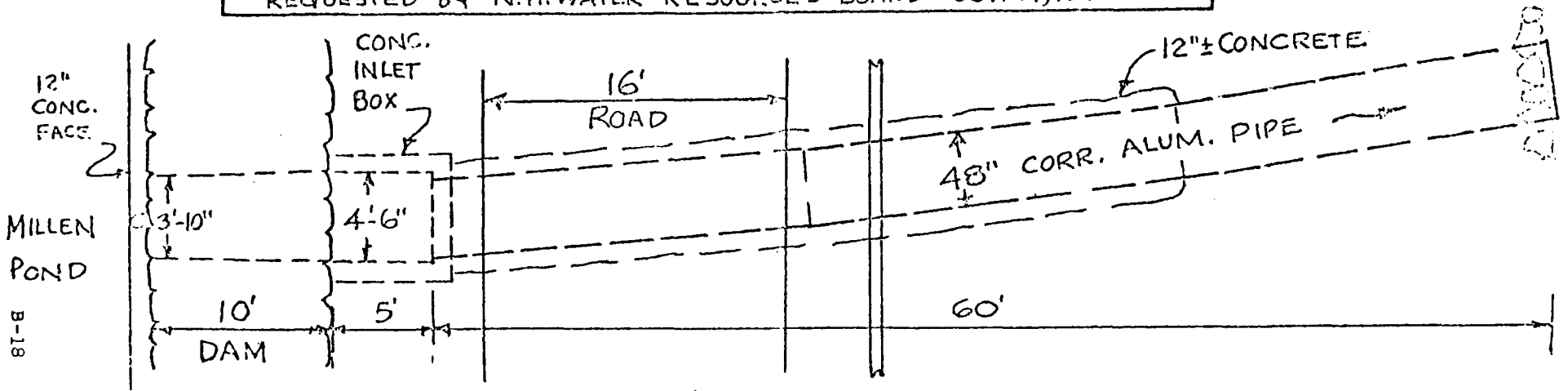
LILLEN LAKE IN WASHINGTON
Faulkner & Colony
September 23,1937

PLANS AND DETAILS

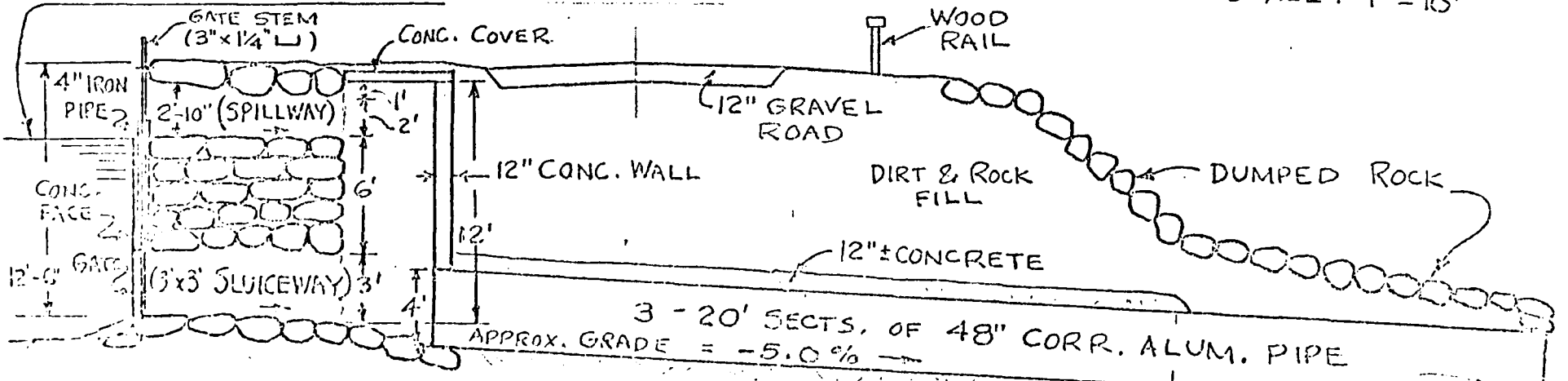
RECONST OF OUTLET - MILLEN POND DAM
WASHINGTON, N.H.

CONST. BY CURTIS ROWE, HILLSBORO, N.H. BY CONTRACT FOR $2,850 PLUS 60' CULV. @ $11.94 = 716.40. = TOTAL $3,566.40
BUILT JULY 13-18, 1970 FROM RECOM. BY F.C. MOORE OF N.H. WATER RESCS. BOARD FOLLOWING INSP. JUNE 9, 1970 AT REQ. OF SELECTMEN.

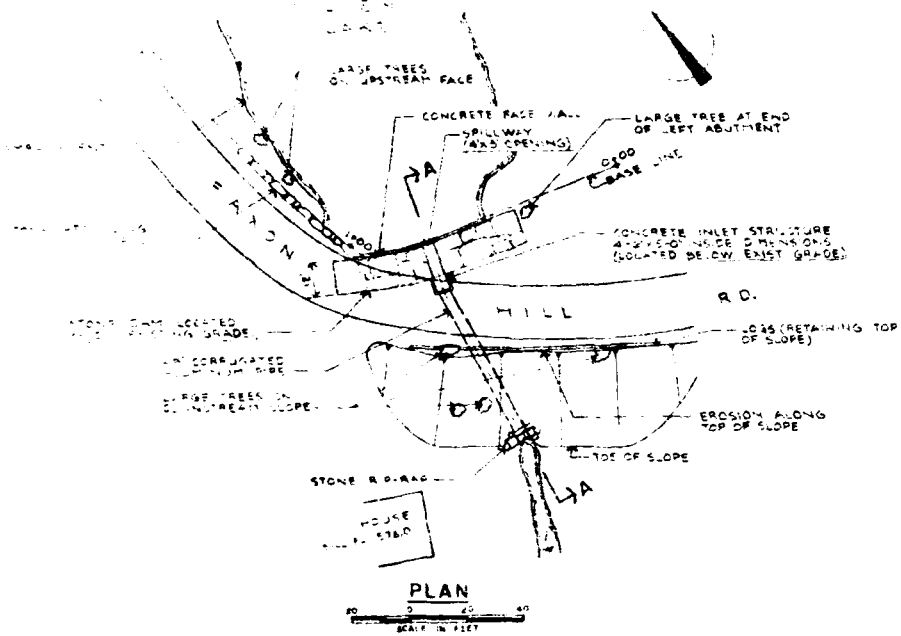
PLAN BY: P.E. ROLFE, P.E., FOR SELECTMEN OF WASHINGTON. DRAWN NOV. 12, 1970 TO ACCOMPANY AN "INTENT TO CONSTRUCT" REQUESTED BY N.H. WATER RESOURCES BOARD OCT. 14, 1970



PLAN

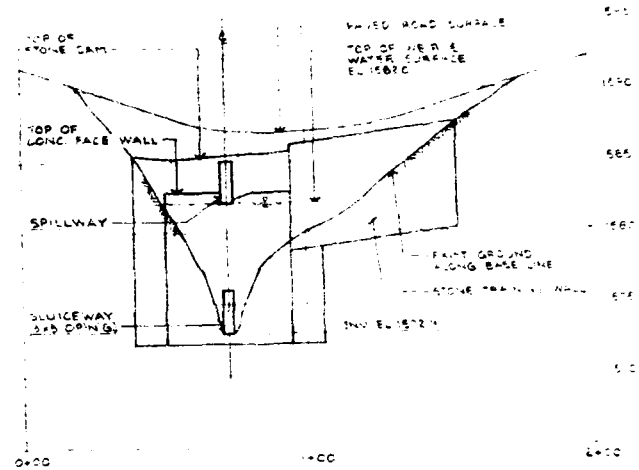


ELEVATION

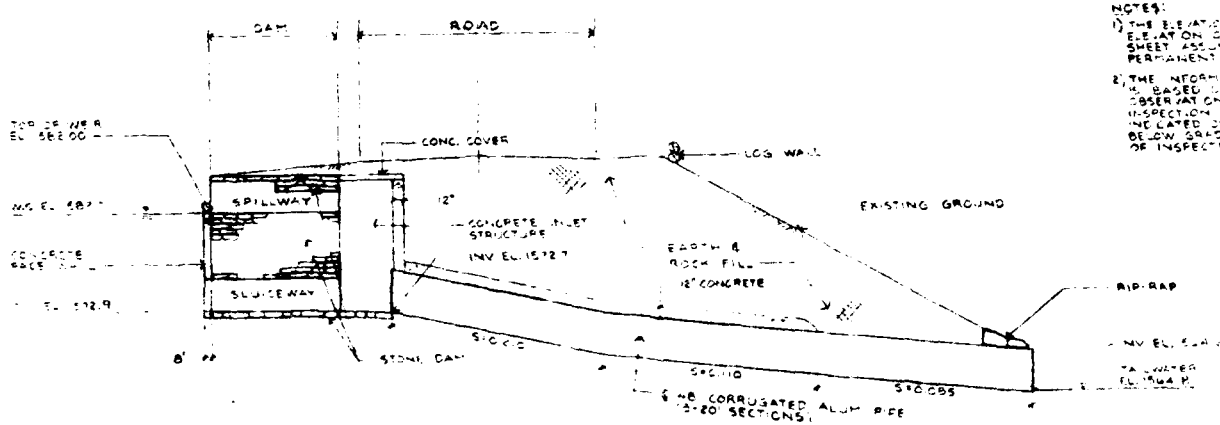


PLAN

SCALE IN FEET



PROFILE
(LOOKING DOWNSTREAM)



SECTION A-A

NOTES:

1) THE ELEVATIONS SHOWN ARE BASED ON AN ELEVATION OF 582 SHOWN ON [illegible] SHEET ASSUMED TO BE 600. ELEVATION AT PERMANENT SPILLWAY CREST

2) THE INFORMATION SHOWN ON THIS [illegible] IS BASED ON EXISTING SHEETS AND OBSERVATIONS MADE DURING THE FIELD INSPECTION. DITCH, CULVERTS, WATER COURSES INDICATED ON THIS DRAWING WHICH ARE BELOW GRADE OR LATER DURING THE TIME OF INSPECTION WERE NOT VISIBLE

MILLEN LAKE DAM

APPENDIX C

SELECTED PHOTOGRAPHS

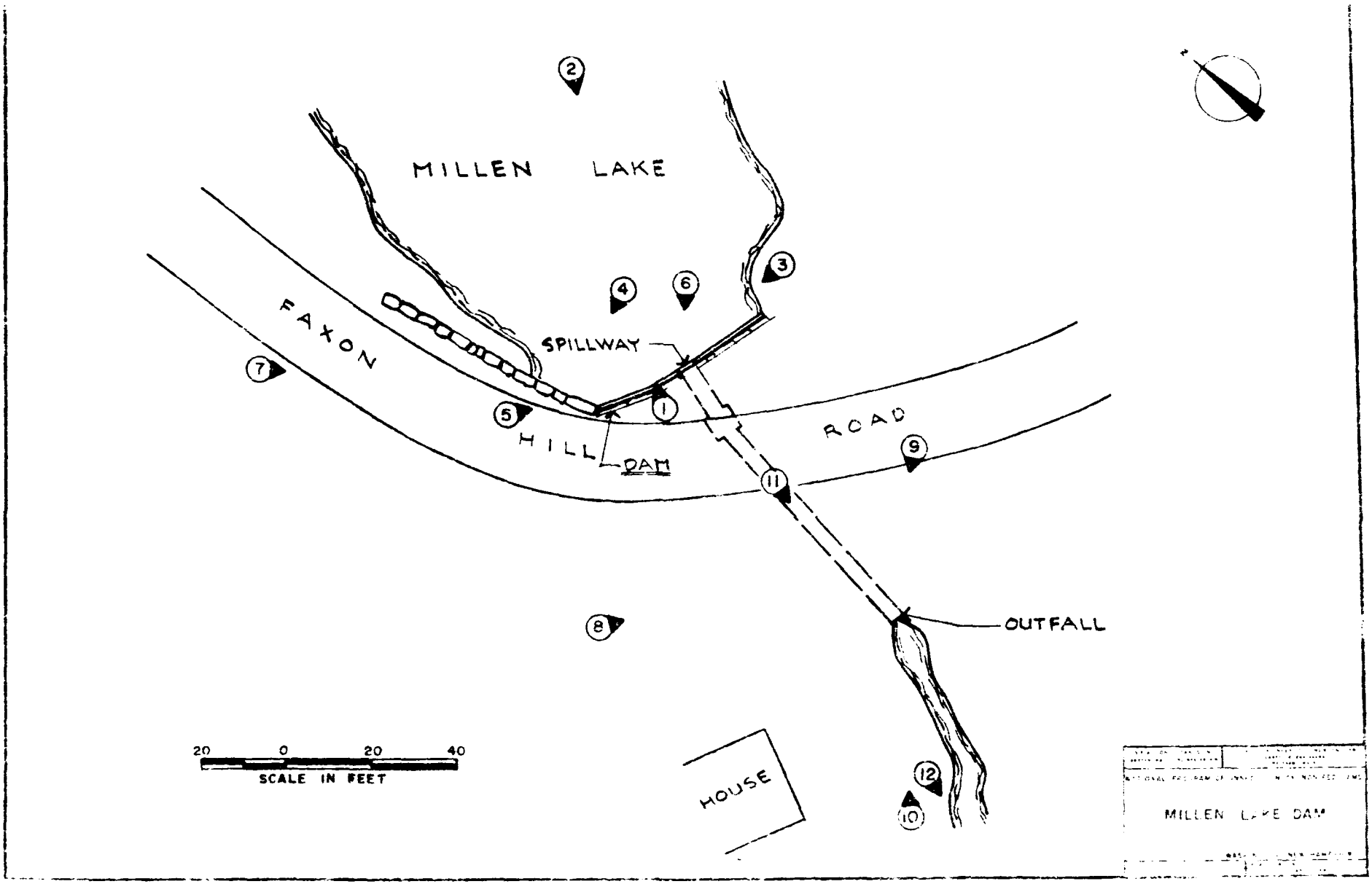

MILLEN LAKE
FAXON
HILL
SPILLWAY
DAM
ROAD
OUTFALL
HOUSE
1
2
3
4
5
6
7
8
9
10
11
12
20 0 20 40
SCALE IN FEET
MILLEN LAKE DAM

Photo No. 1 - General view of lake from dam.

Photo No. 2 - General view of dam from lake.

Photo No. 5 - View of upstream face of dam and left abutment from right abutment.

Photo No. 6 - Closeup view of upstream face of spillway.

Photo No. 9 - View of downstream slope of dam and building from top of dam.

Photo No. 10 - View of downstream slope of dam and outlet pipe from right side of downstream channel

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

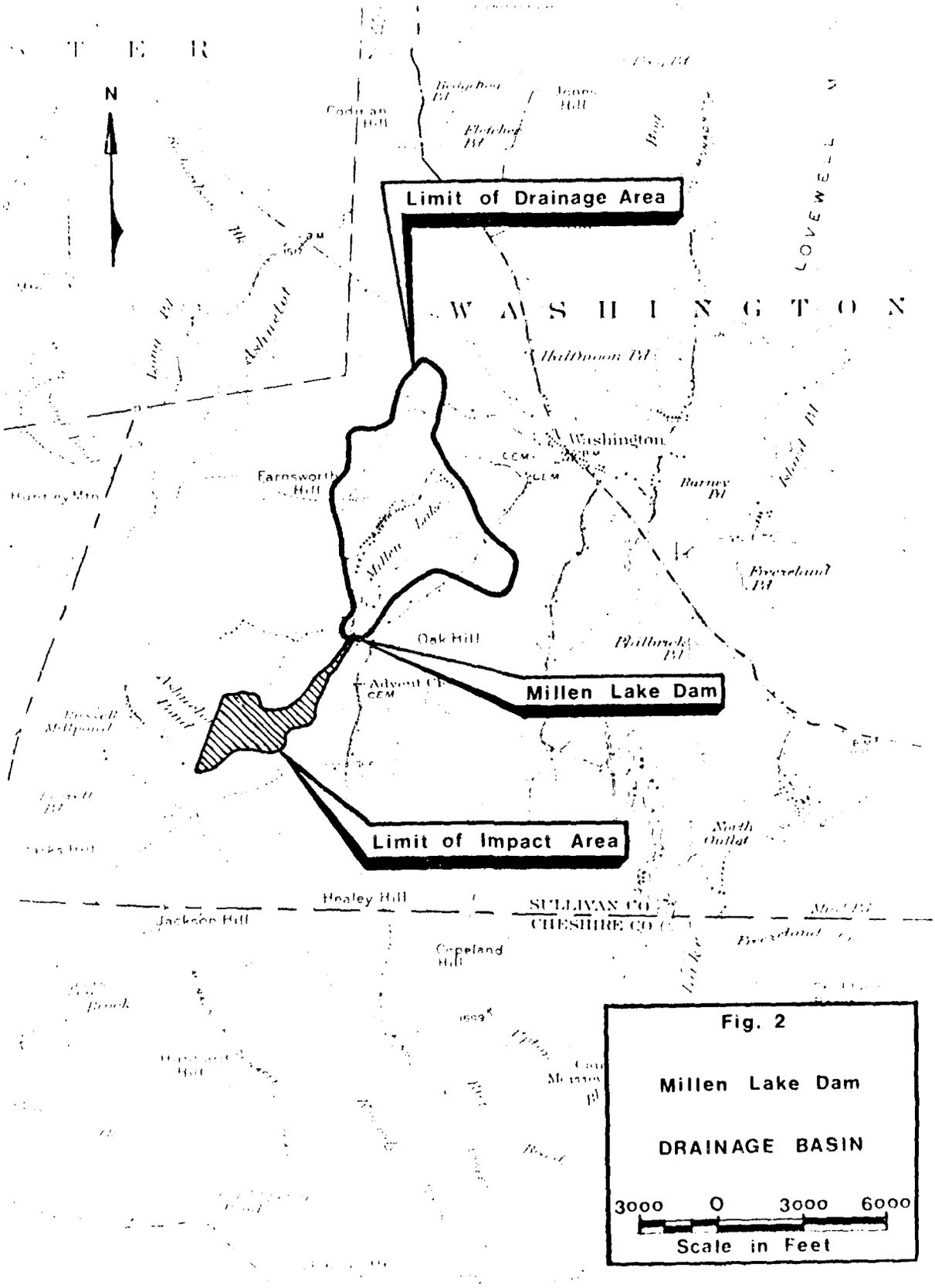


Fig. 2

Millen Lake Dam

DRAINAGE BASIN

SIEA CONSULTANTS INC.
ENGINEERS / PLANNERS
BOSTON, MASS.
ROCHESTER, N.H.

CLIENT Army Corps | JOB NO. 274-7901 | PAGE 1 of 5
PROJECT Milan Lake Dam | COMPTD. BY BNP | DATE 11/29/90
DETAIL Hydrologic Calcs | CK'D. BY MJS | DATE

I. Basic Data

A Drainage Area

1. .23 sq. mi – as derived [illegible] and later planimetered

2. drainage area would [illegible] as mountainous for estimating PMF Peak Flow Rates

B. Dam and Storage Information

1. Size Classification: INTERMEDIATE
based on storage (≥1000 ac-ft and <50,000 ac-ft)

as indicated below storage at crest of dam estimated to be 1235 acre-ft

2. Hazard Potential: SIGNIFICANT

A major breach in dam could result in the destruction of the house just around the dam and would do [illegible] road crossing the dam. while potential for loss of life exists (however this does not appear to be likely)

3. Storage Information

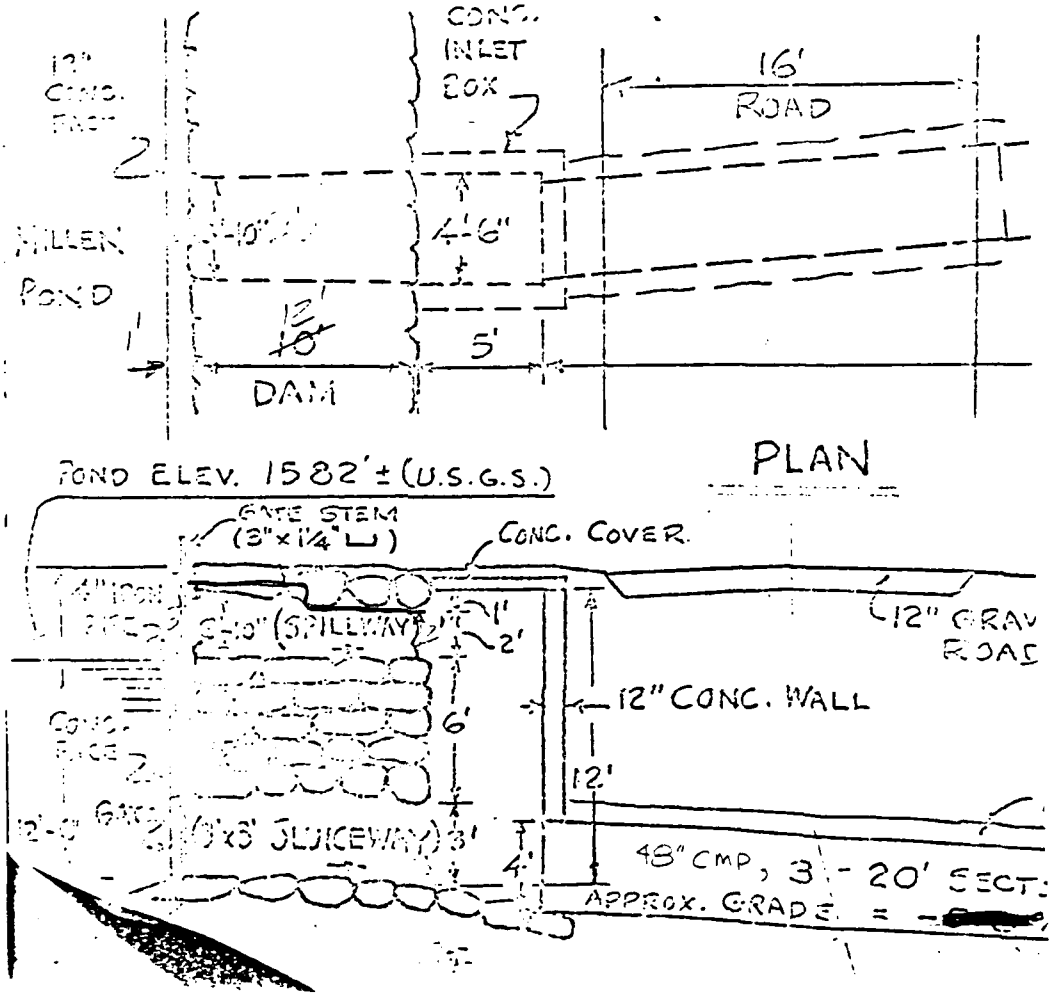
Descriptive Information	Elevation * (feet)	Surface * Area (acres)	Storage (acre-ft.)
1600' Contour	1600.0	230	
Crest of dam	1587.2	177	1235
Invt. of spillway	1582.0	156	420
[illegible]	[illegible] 581.3	156	465

* Notes: (1) elevations : NGVD
(2) normal pool taken to correspond with pool shown on U.S.G.S. crest elevation of pool (1523.0) assumed to correspond with invert of spillway
(3) surface area at crest of dam determined by interpolating between the surface areas determined by those shown on U.S.G.S. quad and 1000' contour
(4) storage at invert of spillway computed by dividing reservoir into pyramidal frustrum sections and determining the volume of each section with the formula for the volume of a pyramidal frustrum

C. Spillway Information

1. Discharge normally occurs through the spillway near the center of the dam. The 3' x 3' spillway control near the face of the dam is situated to control the reservoir water surface elevation at the invert of the spillway (see drawings next page). The spillway and flume connect to a common inlet box which discharges into a 48" CMP, which discharges to the stream channel at the downstream toe of the dam.

The spillway structure measures approximately 3' wide x 3' high at the face of the dam. However the flume decreases to 2.0' in height and increases in width to 4.5' as it approaches the inlet box. The flume conveys discharge through the spillway with a constant 2.0' x 4.5' cross-section.



a. for subsequent calculations it was assumed that the sluiceway gate is closed and leakage occurs only through the spillway structure.

2. Discharge through the Spillway

a. given by broad-crested weir equation for a reservoir surface up to 2.0' above the spillway invert (elev 1584.0

$$Q = C_L H^{3/2}$$ (

where: Q = discharge

C = discharge coefficient = 3.0

L = length of crest

H = head over weir crest

b. given by orifice discharge equation for reservoir water surface elevations greater than 1584.0'

$$Q = C \times \sqrt{2gh}$$

where: Q = discharge, cfs
C = coefficient of discharge, use 0.6
a = area of orifice, ft²
g = acceleration due to gravity = 32.2 ft/sec²
h = head on centroid of orifice, ft

II. Estimate Effect of Surcharge Storage on Maximum Probable Discharge

A. Develop stage discharge curve for outflow from dam

1. define sources of outflow

a discharge through spillway - defined above

b discharge over dam - above elevation - 1587.2
(1) use broad-crested weir equation as defined above

c discharge through natural channel upstream from dam - above elevation 1579.9
(1) flow controlled by culvert beneath road - with elevation 1584.6 at which time flow will start over road

(2) discharge Through culvert - 2 feet [illegible]
21 feet long

(a) use Manning equation until Crown submerged - with $n = 0.024$ and slope = 0.0238

(b) with Crown submerged use rearranged headloss equation for culvert - determined by American Iron + Steel Institute, Handbook of Steel Drainage and Highway Construction Products

$$H = \frac{29 n^2 L}{R^{1.33}} \frac{V^2}{2g}$$

$$\Downarrow \quad \text{(for } Q\text{)}$$

$$Q = \left(\frac{H 2g A^2 R^{1.33}}{29 n^2 L} \right)$$

Where: Q = discharge rate
H = head above tailwater [illegible]
g = gravitational [illegible]
A = area of culvert, ft²
R = hydraulic radius
n = Manning [illegible]
L = length of culvert, ft
V = [illegible]

(3) discharge over road - above elevation 1584.7
(a) use broad-crested weir equation with $C = 2.6$

2. Discharge through spillway - elevation 1582' to 1594'

Elevation (feet)	C	L (feet)	H (feet)	Q (cfs)
1582.0	—	—	0	0
1583.0	2.6	4.5	1.0	12
1584.0	2.6	4.5	2.0	33

3. Discharge through spillway - crest elevation 1584'

Elevation (feet)	C	a (feet²)	h (feet)	Q (cfs)
1585.0	0.6	9.0	2.0	61
1586.0	↓	↓	3.0	75
1587.0			4.0	87
1588.0			5.0	97
1589.0			6.0	106
1590.0			7.0	115
1591.0			8.0	123
1592.0			9.0	130
1593.0	↓	↓	10.0	137

4. Discharge over dam crest

Profile of dam presents a trapezoidal cross-section perpendicular to the direction of flow, consequently the depth of flow will vary across the crest of the dam. To determine discharge will divide dam cross-sectional profile into three segments, two triangular segments and a "rectangular". The discharge at various elevations will be computed for each segment, and then added to give the total discharge at each elevation

a. "east" triangular segment

Elevation (feet)	C	L (feet)	H_{avg} (feet)	Q (cfs)
1587.2	--	—	0	0
1588.0	2.6	14	0.4	4
1589.0		29	0.9	34
1590.0		45	1.4	124
1591.0		60	1.9	253
1592.0		76	2.4	422
1593.0	↓	92	2.9	621

b. rectangular segment

Elevation (feet)	C	L (feet)	H, avg (feet)	Q
1587.2	—	—	0	0
1588.0	2.6	75	0.6	91
1589.0			1.6	395
1590.0			2.6	819
1591.0			3.6	1330
1592.0			4.6	1920
1593.0			5.6	2590

c. "west" triangular segment

Elevation (feet)	C	L (feet)	H, avg (feet)	Q
1587.2	—	—	0	0
1588.0	2.6	6	0.2	1
1589.0		23	0.7	35
1590.0		53	1.2	130
1591.0		56	1.7	323
1592.0		72	2.2	511
1593.0		93	3.2	1010

d. Total discharge over dam crest

Elevation (feet)	Q east Δ	Q rectangle	Q west Δ	TOTAL Q
1587.2	0	0	0	0
1588.0	9	91	1	101
1589.0	64	395	35	494
1590.0	194	819	130	1140
1591.0	401	1330	323	2065
1592.0	735	1920	611	3270
1593.0	1190	2590	1010	5070

5 Discharge through channel upstream from dam

a. Culvert – from invert to crown

$$Q_{full} = (1ft)^2 \pi \left(\frac{1.486}{0.024}\right)\left(\frac{2'}{4}\right)^{2/3}(0.0238)^{1/2}$$

$$= 18.9 \text{ cfs}$$

Elevation (feet)	Depth of flow	% of Q_{full} *	Q cfs
1579.9	0	0	0
1580.0	0.1	0.05	1
1581.0	1.1	0.55	10
1582.0	2.1	Crown	Submerged (see below)

* via Hydraulic Elements Chart

b. Culvert – with crown submerged

(1) In equation on p.5 all variables but Q and H are constant therefore reduce equation to

$$Q = \text{Constant } H^{1/2}$$

$$Q = \left[\frac{(2)(32.2)\left[\pi(1)^2\right]^2\left(\frac{2}{4}\right)^{1.33}}{29(0.024)^2(2.1)}\right]^{1/2} H^{1/2}$$

$$Q = 26.85 \; H^{1/2}$$

Elevation (feet)	Constant	H	Q cfs
1582.0	26.85	0.6	21
1583.0	↓	1.6	34
1584.0		2.6	43
1585.0		3.6	51
1586.0		4.6	59

b. Culvert - Elliptical arch - inverted

Elevation feet	Constant	H	Q cfs
1587.0	26.35	5.6	64
1588.0	↓	6.6	69
1589.0		7.6	74
1590.0		8.6	79
1591.0		9.6	83

c. discharge over road above elevation = 1584.6 ft

Elevation feet	C	L (feet)	Avg H feet	Q cfs
1584.6	—	—	0	0
1585.0	2.6	15	0.2	3
1586.0	↓	70	0.7	107
1587.0		125	1.2	427
1588.0		190	1.7	1037
1589.0		235	2.2	1993
1590.0		290	2.7	3345
1591.0		345	3.2	5135

d Total discharge Through channel upstream from dam

Elevation (feet)	Q culvert	Q road	Q TOTAL (cfs)
1579.9	0	0	0
1580.0	1	0	1
1581.0	10	0	10
1582.0	21	0	21
1583.0	34	0	34
1584.0	43	0	43
1585.0	51	3	54
1586.0	58	107	165
1587.0	64	427	491
1588.0	69	1037	1110
1589.0	74	1993	2070
1590.0	79	3345	3420
1591.0	83	5135	5220

6. Total discharge from project site

Elevation feet	Q spillway	Q overtopping	Q	Q TOTAL
1579.9	0	0	0	0
1580.0	0	0	1	1
1581.0	0	0	10	10
1582.0	0	0	21	21
1583.0	12	0	34	46
1584.0	33	0	43	76
1585.0	61	0	54	115
1586.0	75	0	165	240
1587.0	87	0	491	578
1588.0	97	101	1110	1308
1589.0	106	494	2070	2670
1590.0	115	1140	3420	4670
1591.0	123	2060	5220	7400

Discharge vs Elevations shown graphically on Figure 1

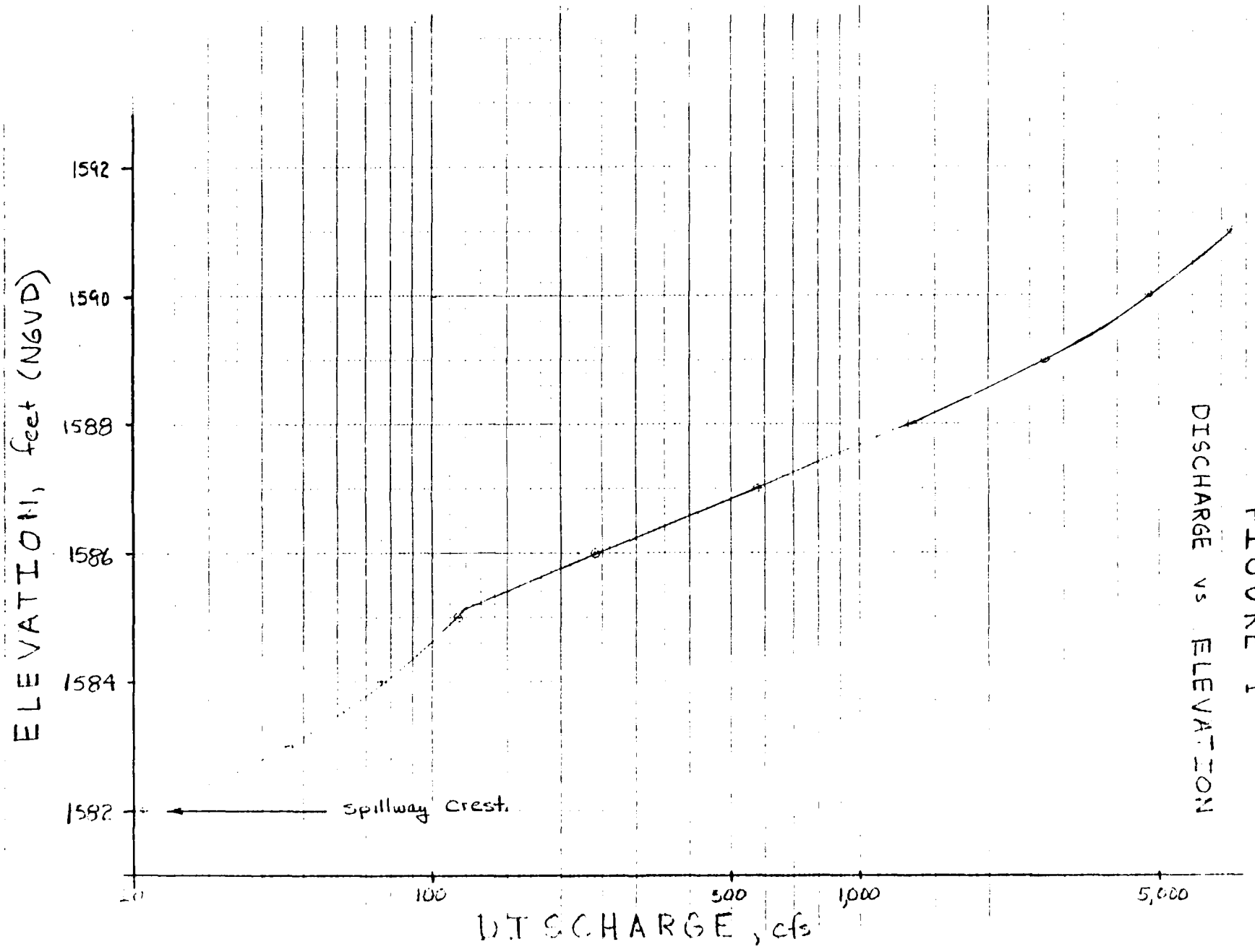


FIGURE 1

DISCHARGE vs ELEVATION

B. Effect of surcharge storage on max. prob. discharge

1. Pertinent Data

a. Drainage area = 1.23 square miles
b. Characteristics of basin - Mountainous
c. Test flood = PMF (Intermediate size and Significant Hazard)
d. Follow Army Corps' procedure

2. STEP 1: Determine Peak Inflow Q_{P1} from Guide Curve

a. the maximum probable discharge was estimated to be 2700 cfs/sq.m. (extrapolated from Guide curve)

$\therefore$ PMF = (2700 cfs/sq.m) (1.23 sq.m.)

= 3320 cfs

3. STEP 2: Determine surcharge height to pass Q_{P1}, STR_1 and Q_{P2}

a. from Figure 1 determine surcharge height to pass Q_{P1} = 3320 cfs

Surcharge elevation = 1599.2
elev. of spillway crest = 1592.0
Surcharge height = 7.2

b. determine volume of surcharge STR_1 in inches of runoff

(1) determine volume of storage in acre-feet between surcharge elevation from Figure 1 = 1599.2 and spillway crest elevation 1592.0

(2) average surface area between surcharge elevation 1599.2 and spillway crest elevation 1592.0

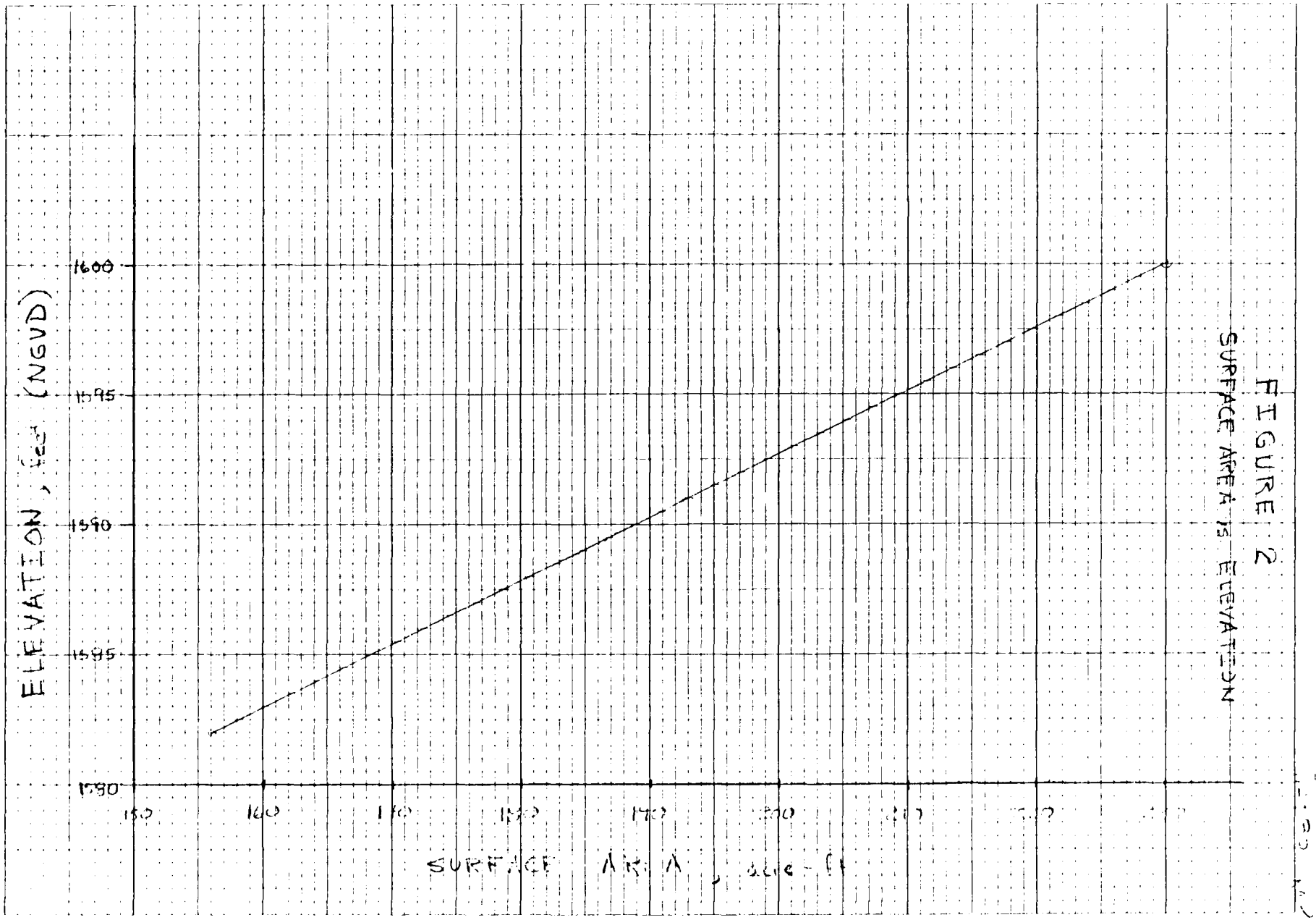


FIGURE 2
SURFACE AREA VS ELEVATION

(3) Multiply surcharge (depth above elevation 583.5 ft) times average surface area to determine volume of storage in acre-ft for input in routing equation

$$STOR_1 = \frac{\text{Volume of storage (as acre-inches)}}{\text{drainage area}}$$

$$STOR_1 = \frac{\left(\frac{185 \text{ acres} + 156 \text{ acres}}{2}\right)(7.2 \text{ ft})(12''/\text{ft})}{(1.235 \text{ sq m.})(640 \text{ acres/sq m.})}$$

$$STOR_1 = 13.7 \text{ inches}$$

c. determine Q_{P2}

$$Q_{P2} = Q_{P1}\left(1 - \frac{STOR_1}{19''}\right)$$

$$Q_{P2} = (3320 \text{ cfs})\left(1 - \frac{13.7''}{19''}\right)$$

$$Q_{P2} = 52 \text{ cfs}$$

4. STEP 3: Determine surcharge [illegible] Q_{P2} and then Q_{P3}

a. From Figure 1 determine [illegible] height to pass

$Q_{P2} = 52$ cfs

Surcharge elevation = 583.5

Elevation [illegible] = [illegible]

Surcharge height 1.5 ft

Surface area @ 583.5 = [illegible]

b. determine $STOR_2$

$$STOR_2 = \frac{\left(\frac{162\text{ac} + 156\text{ac}}{2}\right)(1.5\text{"})(\quad}{.123 \quad (640 \text{ acres/Sq mi})}$$

$$= 3.6 \text{ inches}$$

c. Average $STOR_1$ and $STOR_2$

$$STOR_{AVG} = \frac{STOR_1 + STOR_2}{2}$$

$$STOR_{AVG} = \frac{18.7" + 3.6"}{2}$$

$$STOR_{AVG} = 11.2 \text{ inches}$$

d. determine Q_{P3}

$$Q_{P3} = (3320 \text{ cfs})\left(1 - \frac{11.2}{19}\right)$$

$$Q_{P3} = 360 \text{ cfs}$$

5. STEP 4: Determine surcharge height for Q_{P3} and $STOR_3$

a. from Figure 1 surcharge height for Q_{P3} = 3.0 ft

surcharge elevation = 533.0

dam freeboard = 530.0

surcharge height = 6.0 ft

pond surface area @ 1597.M = 30.5 ac

b. determine STOR

$STOR_3$ = 15.4 inches

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{15.4'' + 11.2''}{2}$$

$STOR_{AVG}$ = 13.3 inches

d. determine Q_{P4}

$$Q_{P4} = (3320 \text{ cfs})\left(1 - \frac{13.3''}{19''}\right)$$

Q_{P4} = 996 cfs

6. STEP 5: Determine surcharge height for Q_{P4} and $STOR_4$

a. From Figure 1 surcharge height for Q_{P4} = 996 cfs

Surcharge elevation = 1597.7'

[illegible] = [illegible]

[illegible] = 5.7'

2nd surface @ 1597.7' = [illegible] acres

b. determine $STOR_4$

$$STOR_4 = \frac{\left(\frac{179 \text{ ac} - 150 \text{ ac}}{2}\right)(5.7 \text{ ft})\left(12''/1'\right)}{(1.23 \text{ sq m})(640 \text{ ac}/1 \text{ sq m})}$$

$STOR_4$ = 14.5 inches

c. determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{13.3'' + 14.5''}{2}$$

= 13.9 inches

d. determine Q_{PS}

$$Q_{PS} = (3320 \text{ cfs})\left(1 - \frac{13.9''}{9''}\right)$$

$$Q_{PS} = 890 \text{ cfs}$$

7. STEP 6: Determine surcharge height for Q_{PS} and $STOR_S$

a. From Figure 1 surcharge height for Q_{PS} = 890 cfs

Surcharge elevation = 1597.5
spillway weir crest elev. = 1592.0'
Surcharge height = 5.5 feet

Surface area @ 1597.5' ≈ 173.5 acres

b. determine $STOR_S$

$$STOR_S = \frac{\left(\frac{173.5\text{ac} + 156\text{ac}}{2}\right)(5.5\text{ in})}{(1.23\text{sq mi})(640\text{ac/sq mi})}$$

$STOR_S$ = 14.0 inches

c determine $STOR_{AVG}$

$$STOR_{AVG} = \frac{13.9 + 14.0''}{2}$$

$STOR_{AVG}$ = 13.95 inches

$STOR_S$ and $STOR_{AVG}$ agree to within 1% since we accept maximum pipeline discharge equal to 890 cfs @ surcharge elev = 1597.5

3. In Conclusion

a. Test flood discharge = 340 cfs and will overtop dam by

b. Spillway capacity

(1) water surface at crest of dam - elev. = 1597.2'

$$Q = (0.6)(9.0\ ft^2)\left[(32.2)(2)(4.2\ ft)\right]^{1/2} = 89\ cfs$$

(2) water surface at test flood elevation - elev = 1597.5'

$$Q = (0.6)(9.0\ ft^2)\left[(32.2)(2)(4.5\ ft)\right]^{1/2} = 92\ cfs$$

c. Sluiceway capacity

(1) water surface at crest of dam - elev. = 1597.2'

$$Q = (0.6)(9\ ft^2)\left[(2)(32.2)(1587.2' - 1574.4')\right]^{1/2} = 155\ cfs$$

(2) water surface at test flood elevation - elev = 1597.5'

$$Q = (0.6)(9\ ft^2)\left[(2)(32.2)(1587.5' - 1574.4')\right]^{1/2} = 157\ cfs$$

III. Using "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs examine impact of dam failure

1. Pertinent Data

a. Failure occurs when reservoir level at crest of dam - elevation = 1587.2 feet

b. Storage at crest elevation estimated to be approximately 1285 acre-feet

A. Reach 1

1. STEP 1: Determine reservoir storage at time of failure

from previous calcs. storage = 1285 acre-ft

2. STEP 2: Determine Peak Failure Outflow Q_{P1}

$$Q_{P1} = (8/27)\, W_b \sqrt{g}\, Y_o^{3/2}$$

where: W_b = Breach width (use 40% of total length)
= (0.40) (115 feet)
= 46 feet

Y_o = Total height from channel bed to pool level at failure
≈ 14.3 feet

1587.2'
1572.9'
14.3 feet

$$Q_{P1} = (8/27)(46\text{feet})\,(32.2)^{1/2}(14.3\text{f}\ldots)^{3/2}$$

$Q_{P1} \approx 4190$ cfs.

Pre-failure flow is neglected compared to the dam failure discharge and ... not been included as part of these calculations

3. STEP 3: Prepare stage-discharge curve for Reach 1

a. Pertinent Data

(1) Reach length = 210 feet
(2) Channel slope = 0.03
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 10 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{p_1} = 4190 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 9.9 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(9.9\text{ ft})(10\text{ ft} + 55\text{ ft})$$
$$= 322\text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(210\text{ ft})(322\text{ ft}^2)}{43{,}560\text{ ft}^2/\text{acre}}$$

$$= 1.6 \text{ acre-feet}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P2(TRIAL)}$

$$Q_{P2(TRIAL)} = Q_{P1}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P2(TRIAL)} = (4190\text{ cfs})\left(1 - \frac{1.6\text{ ac-ft}}{129.5\text{ ac-ft}}\right)$$

$$Q_{P2(TRIAL)} = 4180 \text{ cfs}$$

c. Compute V_2 using $Q_{P2(TRIAL)}$

From Figure 3 determine stage for $Q_{P2(TRIAL)}$

Stage = 9.9 feet

X-area = (0.3)(9.9 feet)(10ft + 55ft)

$\approx 322\ ft^2$

$$V_2 = \frac{(210\ feet)(322\ ft^2)}{43560\ ft^2/acre}$$

$V_2 = 1.6$ acre-ft

d. Average V_1 and V_2 and compute Q_{P2}

(1) $$Vavg = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{1.6\ ac\text{-}ft + 1.6\ ac\text{-}ft}{2}$$

Vavg = 1.6 acre-ft

(2) $$Q_{P2} = Q_{P1}\left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P2} = (4190\ cfs)\left(1 - \frac{1.6}{1295}\right)$$

$Q_{P2} = 4180$ cfs

B Reach 2

3. STEP 3: Prepare stage-discharge curve for Reach 2

a. Pertinent Data

(1) Reach length = 890 feet
(2) Channel slope = 0.09
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 10 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P2} = 4180 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 4.7 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

$$\text{X-area} = (0.5)(4.7 \text{ ft})(10 \text{ ft} + 99 \text{ ft})$$
$$= 254 \text{ ft}^2$$

$$\text{Volume} = V_1 = \frac{(254 \text{ ft}^2)(890 \text{ ft})}{43{,}560 \text{ ft}^2/\text{acre}}$$

$$= 5.2 \text{ acre-ft}$$

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P3(TRIAL)}$

$$Q_{P3(TRIAL)} = Q_{P2}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P3(TRIAL)} = (4{,}180 \text{ cfs})\left(1 - \frac{5.2}{235}\right)$$

$$Q_{P3(TRIAL)} = 4{,}160 \text{ cfs}$$

c. Compute V_2 using $Q_{P3(TRIAL)}$

From Figure 3 determine stage for $Q_{P3(TRIAL)}$

Stage = 4.7 feet

X-area = (0.5)(4.7 ft)(10 ft + 98 ft)
= 254 ft²

$$V_2 = \frac{(254 ft^2)(890 ft)}{43,560 ft^2/acre}$$

V_2 = 5.2 acre-ft

d. Average V_1 and V_2 and compute Q_{P3}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{5.2 ac\text{-}ft + 5.2 ac\text{-}ft)}{2}$$

Vavg = 5.2 acre-ft

(2) $Q_{P3} = Q_{P2}\left(1 - \frac{Vavg}{S}\right)$

$$Q_{P3} = (4,180 cfs)\left(1 - \frac{5.2}{1295}\right)$$

Q_{P3} = 4,160 cfs

C Reach 3

3. STEP 3: Prepare stage-discharge curve for Reach 3

a. Pertinent Data

(1) Reach length = 400 feet
(2) Channel slope = 0.05
(3) Manning n = 0.05
(4) Channel shape - trapezoidal
(5) Base width ≈ 10 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P3} = 4,160 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 5.2 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

X-area = (0.5)(5.2 ft)(10ft + 108 ft)
= 307 ft²

$$\text{Volume} = V_1 = \frac{(307 \text{ ft}^2)(400 \text{ ft})}{43\,560 \text{ ft}^2/\text{acre}}$$

= 2.8 acre-ft

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P4(TRIAL)}$

$$Q_{P4(TRIAL)} = Q_{P3}\left(1 - \frac{V_1}{S}\right)$$

$$Q_{P4(TRIAL)} = \left(4{,}160 \text{ cfs}\right)\left(1 - \frac{2.8}{23.5}\right)$$

$Q_{P4(TRIAL)}$ = 4,150 cfs

c. Compute V_2 using $Q_{P4(TRIAL)}$

From Figure 3 determine stage for $Q_{P4(TRIAL)}$

Stage = 5.2 feet

X-area = $(0.5)(5.2\text{ ft})(10\text{ ft} + 109\text{ ft})$
= 307 ft^2

$$V_2 = \frac{(307\text{ ft}^2)(400\text{ ft})}{43\,560\text{ ft}^2/\text{acre}}$$

V_2 = 2.8 acre-ft

d. Average V_1 and V_2 and determine Q_{P4}

(1) $$Vavg = \frac{V_1 + V_2}{2}$$

$$V_{avg} = \frac{2.8\text{ ac-ft} + 2.8\text{ ac-ft}}{2}$$

Vavg = 2.8 acre-ft

(2) $$Q_{P4} = Q_{P3}\left(1 - \frac{Vavg}{S}\right)$$

$$Q_{P4} = (4,160\text{ cfs})\left(1 - \frac{2.8}{1285}\right)$$

Q_{P4} = 4,150 cfs

D Reach 4

3. STEP 3: Prepare stage-discharge curve for Reach 4

a. Pertinent Data

(1) Reach length = 2650 feet

(2) Channel slope = 0.0057

(3) Manning n = 0.08

(4) Channel shape - trapezoidal ([illegible])

(5) Base width ≈ 10 feet

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P4} = 4150 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 2.9 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

X-area = (0.5)(2.0')(10' + 990') + (0.5)(0.9')(990' - [illegible])
= 1900 ft²

$$\text{Volume} = V_1 = \frac{(1900\ ft^2)(2650\ \text{feet})}{43560\ ft^2/\text{acre}}$$

= 116 acre-ft

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P5(TRIAL)}$

$$Q_{P5(TRIAL)} = Q_{P4}\left(1 - \frac{V}{S}\right)$$

$$Q_{P5(TRIAL)} = (4150\ cfs)\left(1 - \frac{116}{1235}\right)$$

Q_{P5} = 3780 cfs

c. Compute V_2 using $Q_{P3(TRIAL)}$

From Figure 3 determine stage for $Q_{P5(TRIAL)}$

Stage = 2.8 feet

X-area = $(0.5)(2.0')(10' + 990') + (0.5)(0.8')(990' + 1010')$

$\approx$ 1800 ft²

$$V_2 = \frac{(1800\ ft^2)(2650\ feet)}{43{,}560\ ft^2/acre}$$

V_2 = 110 acre-feet

d. Average V_1 and V_2 and compute Q_{P5}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{116\ ac\text{-}ft + 110\ ac\text{-}ft}{2}$$

Vavg = 113 acre-feet

(2) $Q_{P5} = Q_{P4}\left(1 - \frac{V_{avg}}{5}\right)$

$$Q_{P5} = (4150\ cfs)\left(1 - \frac{113}{1235}\right)$$

Q_{P5} = 3790 cfs

E. Reach 5

3. STEP 3: Prepare stage-discharge curve for Reach 5

a. Pertinent Data

(1) Reach length = 5150 feet

(2) Channel slope = 0.00097

(3) Manning n = 0.08

(4) Channel shape - trapezoidal

(5) Base width ≈ 2700 feet (width of pond surface)

b. See Figure 3 for stage-discharge curve

4. STEP 4: Estimate Reach Outflow

a. Determine stage for Q_{P5} = 3790 cfs from Figure 3 and find volume in reach

(1) Stage (depth of flow) = 1.7 feet

(2) Volume in reach = (reach length) (cross-sectional area of channel)

X-area = (0.5)(1.7 ft)([illegible] - 2795)
≈ 4660 ft²

Volume = V_1 = (4660 ft²)(5150 feet) / 43,560 ft²/acre
= 551 acre-feet

$V_1 < \frac{S}{2}$ ∴ reach length OK

b. Determine $Q_{P6(TRIAL)}$

$$Q_{P6(TRIAL)} = Q_{P5}\left(1 - \frac{V}{S}\right)$$

$$Q_{P6(TRIAL)} = (3790 \text{ cfs})\left(1 - \frac{551}{[illegible]}\right)$$

Q_{P6} [illegible] = 2160 cfs

c. Compute V_2 using $Q_{P5(TRIAL)}$

From Figure 3 determine stage for $Q_{P5(TRIAL)}$

Stage = 1.2 feet

X-area = $(0.5)(1.2\text{ ft})(2300\text{ ft} + 2755\text{ ft})$

$\approx 3270\text{ ft}^2$

$$V_2 = \frac{(3270\text{ ft}^2)(5150\text{ feet})}{43{,}560\text{ ft}^2/\text{acre}}$$

$V_2 = 387$ acre-ft

d. Average V_1 and V_2 and compute Q_{P6}

(1) $V_{avg} = \frac{V_1 + V_2}{2}$

$$V_{avg} = \frac{546\text{ ac-ft} + 393\text{ ac-ft}}{2}$$

$V_{avg} = 469$ acre-ft

(2) $Q_{P6} = Q_{P5}\left(1 - \frac{V_{avg}}{S}\right)$

$$Q_{P6} = (3790\text{ cfs})\left(1 - \frac{469}{1235}\right)$$

$Q_{P6} = 2410$ cfs

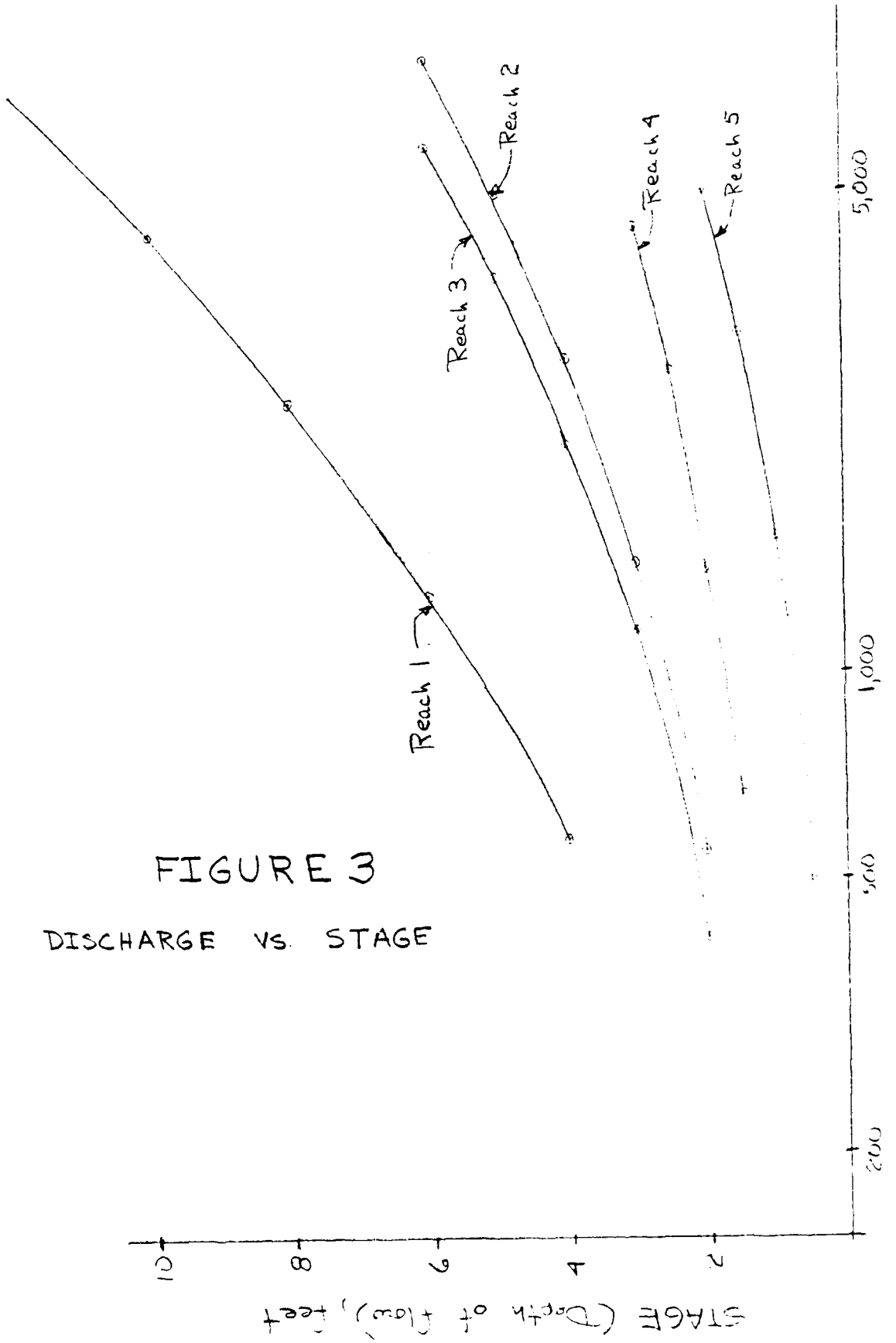
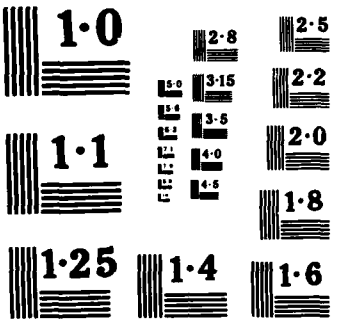


FIGURE 3

DISCHARGE VS. STAGE

AD-A156 423 NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS 2/2
MILLEN LAKE DAM (NH 0..(U) CORPS OF ENGINEERS WALTHAM
MA NEW ENGLAND DIV MAR 80

UNCLASSIFIED F/G 13/13 NL



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

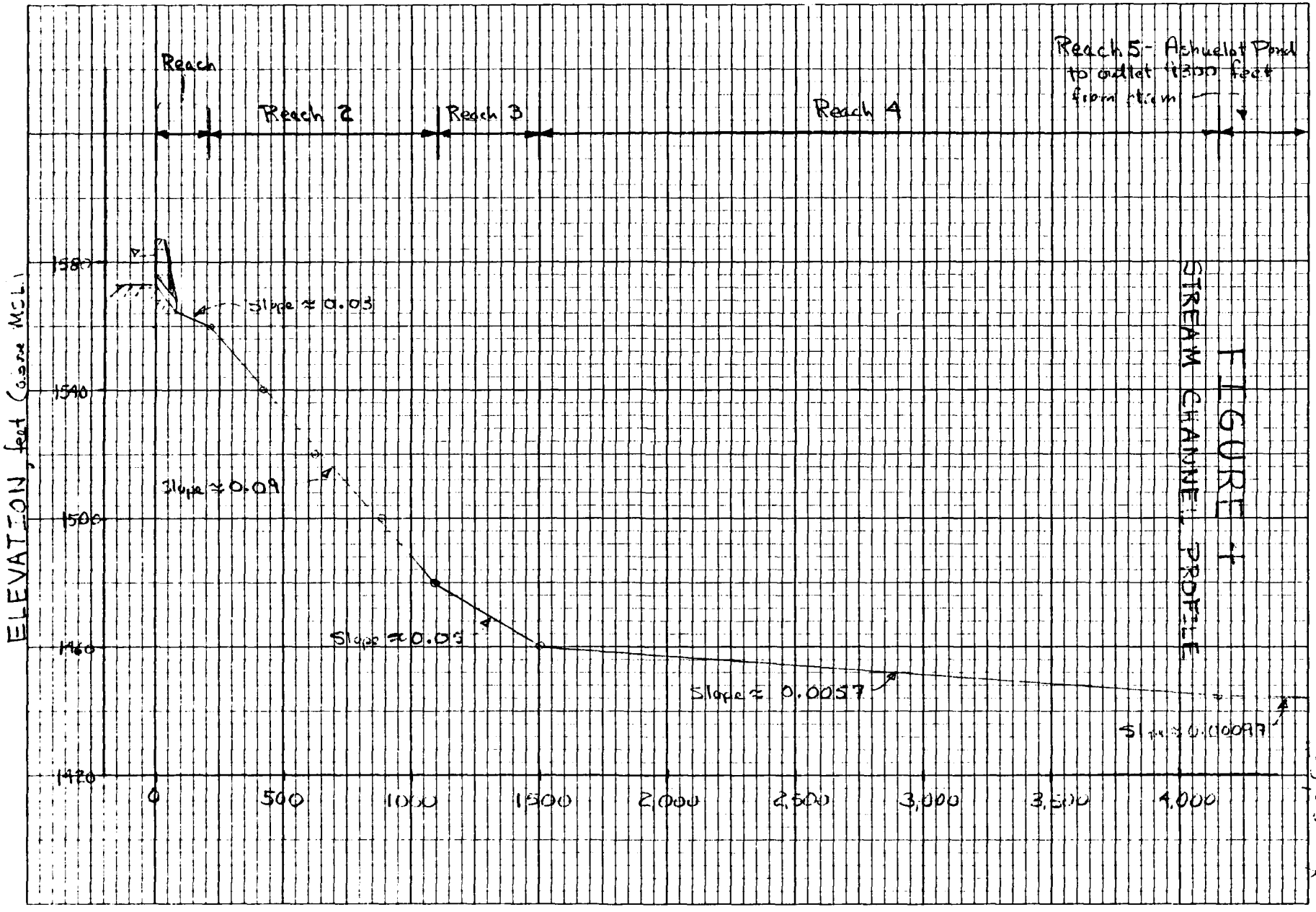


FIGURE 1
STREAM CHANNEL PROFILE

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(9) NAME	(10) LATITUDE (NORTH)	(11) LONGITUDE (WEST)	(12) REPORT DATE DAY | MO | YR
NH	234	NED	NH	019	02				MILLEN LAKE DAM	4309.1	7207.1	24MAR80

(12) POPULAR NAME	(14) NAME OF IMPOUNDMENT
MILLEN POND DAM	MILLEN LAKE

(15) REGION	(16) BASIN	(17) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	08	TR-ASHUELOT RIVER	MARLOW	5	516

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)
PGHFDT	1970	R	23	23	1285	465

DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
NED	N	N	N	N	

(28) REMARKS
21-CONC AND MORTARED STONE FACE WALL 22-RECONSTRUCTION

(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(31) SPILLWAY TYPE	(32) SPILLWAY WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) POWER CAPACITY PROPOSED (MW)	(37) NAVIGATION LOCKS NO	(38) LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
?	115	U	4	80	1950											

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
MILLEN LAKE ASSOC INC	P E ROLFE	CURTIS ROWE

(49) REGULATORY AGENCY DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NH WATER RES BOARD	NH WATER RES BOARD	NH WATER RES BOARD	NH WATER RES BOARD

(50) INSPECTION BY	(51) INSPECTION DATE DAY | MO | YR	(52) AUTHORITY FOR INSPECTION
S E A CONSULTANTS INC	06DEC79	P.L. 92 - 367

(53) REMARKS
47+48-RECONSTRUCTION

END

FILMED

8-85

DTIC